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ANNUAL REPORT

OF THE

Pennsylvania State College

FOR THE YEAR 1896.

PART I—DEPARTMENTS OF INSTRUCTION.

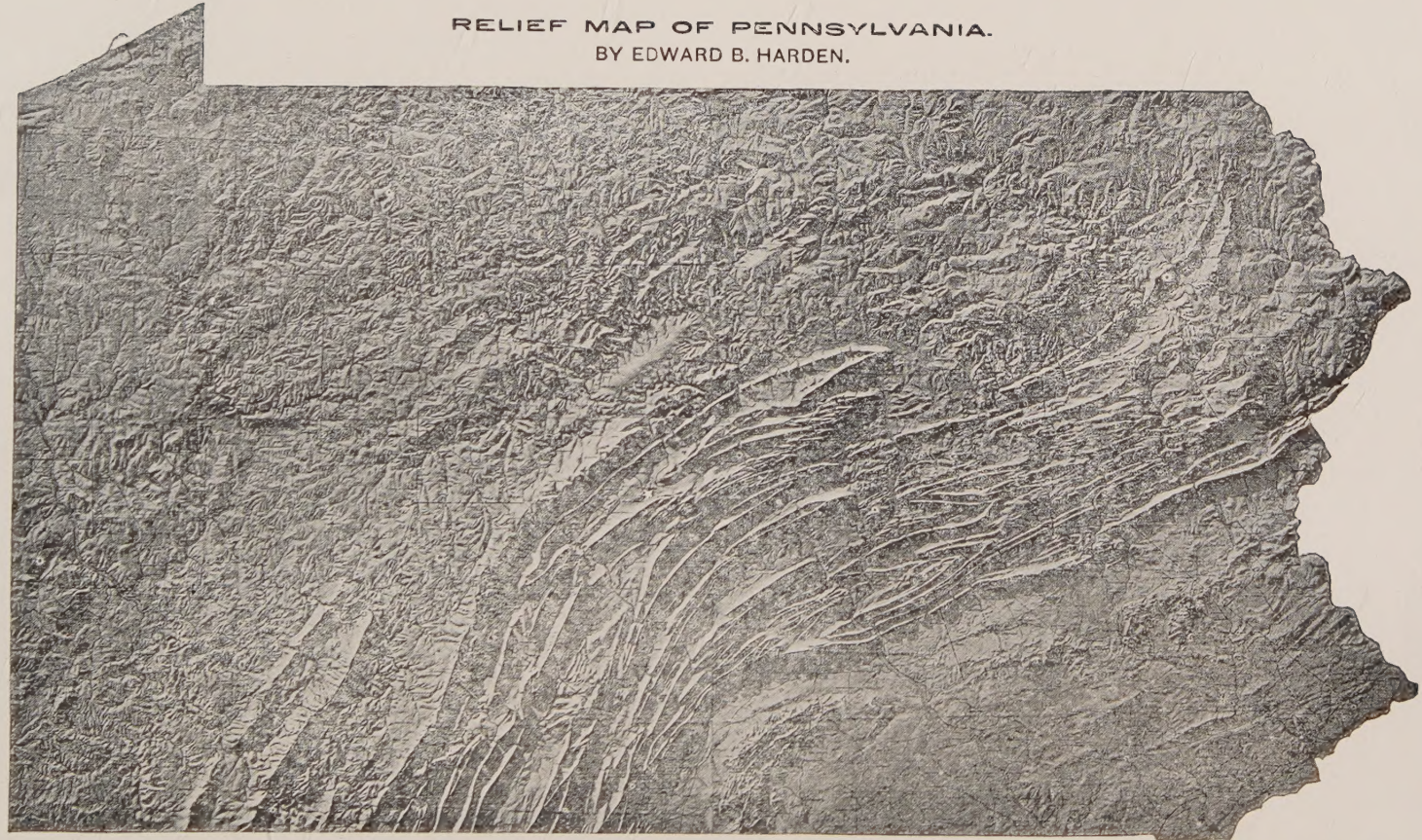
PART II—AGRICULTURAL EXPERIMENT STATION.

CLARENCE M. BUSCH,
STATE PRINTER OF PENNSYLVANIA,
1897.

VIRTUE
LIBERTY AND INDEPENDENCE

RELIEF MAP OF PENNSYLVANIA.

BY EDWARD B. HARDEN.



*The Pennsylvania State College.

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REPORT

OF THE

Pennsylvania State College,

FOR THE YEAR 1896.

HARRISBURG, PA., *January 16, 1897.*

To the Senate and House of Representatives of the Commonwealth of Pennsylvania:

I have the honor herewith to transmit the treasurer's report of the receipts and expenditures of The Pennsylvania State College, for the year 1896, as required by law; and in connection therewith, the reports of the president of the college, and of professors in charge of the departments of instruction. I venture to call attention to these reports as containing matter of great interest to the people of the Commonwealth.

FRANCIS JORDAN,
President of the Board of Trustees.

PRESIDENT'S REPORT.

To the Board of Trustees of The Pennsylvania State College:

Gentlemen: I have the honor to present herewith my report for the year 1896, accompanied by those of professors in several of the departments of the College.

Changes in the teaching force have been made during the year as follows:

At a meeting of the Board June 16, 1896, Mr. T. R. Beyer was promoted from the rank of Instructor in Civil Engineering to that of Assistant Professor of Civil Engineering, and Mr. P. B. Brenneman from the rank of Assistant to that of Instructor in Civil Engineering.

Subsequently, by action of the Executive Committee, under authority given by the Board, the following changes were made: The Rev. Lawrence M. Colfelt, D. D., was appointed Preacher to the College and Professor of Ethics; Mr. Martin G. Benedict, M. A. (Colgate University), Ph. D., Allegheny, was appointed Professor of Pedagogics and in charge of the Sub-Freshman Class; Captain Daniel C. Pearson, Second U. S. cavalry, was detailed by the President of the United States as Professor of Military Science and Tactics in the place of First Lieutenant E. W. McCaskey, Twenty-first U. S. Infantry, whose four years' tour of duty at the College had expired; Mr. Thomas H. Taliaferro, C. E., (Virginia Military Institute), Ph. D. (Johns Hopkins), was appointed Instructor in Mathematics in the place of Mr. George T. Sellew, resigned: Mr. John S. Seibert, B. S. (Lehigh University), was appointed as an additional Instructor in Civil Engineering; Dr. S. B. Newton, A. B. (Williams College), M. D. (University of Pennsylvania), was appointed Physical Director.

The appointment of a preacher to conduct the regular Sunday chapel service was made for the first time in the history of the College, I believe, in the case of Dr. Colfelt. In former years it has been customary to depend upon the services of preachers living within accessible distance of the College, their appointments for preaching being made at dates when they could be absent the whole or part of a Sunday from their own churches. Clergymen of different denominations were thus invited to preach, and the service rendered by them to the College, often at great personal inconvenience and with very small compensation, cannot be too highly appreciated. Everything like denominational or sectarian teaching has always been carefully excluded from the Chapel service, by the good judgment of the preachers themselves, and without the need of sugges-

tion from any quarter. But the inconveniences of the practice were very great in many ways, and it was felt to be an important step in advance when, during a considerable part of last year, the College was able to secure the services of Dr. John M. Gregory, both as a regular preacher and as a lecturer to the Senior Class on branches of political and sociological science, to which he had devoted the study of a life time, and among the teachers of which he holds an eminent position.

At the beginning of the Fall Session in 1896 the College was again fortunate in being able to secure the services of so distinguished and effective a preacher as Dr. Colfelt, and it is a source of gratification that it has been possible to engage him for that service during the whole of the year 1897. In addition to his high intellectual gifts, he brings to his work an unusual sympathy with and appreciation of the needs of youth, at a time when they are taking their first lessons in the real experiences of life and are first facing its deeper problems. While the College is necessarily and happily precluded from giving countenance to any form of sectarianism, all the more, for that very reason, it endeavors to lay the strongest emphasis upon those great fundamentals of life and character which underlie all sound systems of religion and morals alike. It is greatly to be hoped that such provision for this most important of all teaching may become a part of the permanent arrangements of the College.

Captain Pearson comes to his duties here with an honorable record of active service in the army during the war of the Rebellion and ever since, which furnishes to the young men of the College an inspiring example of what the true citizen soldier may do for his country. Captain Pearson's immediate predecessor had brought the battalion to a higher standard of efficiency than it had ever before reached, and there is every reason to believe that the next four years will mark a still further advance. It may not be inappropriate to state, at this point, in answer to a question frequently asked, that the experience of each succeeding year confirms my judgment of the great value of military training as a part of the preparation of young men for the work of life. In addition to the technical knowledge of military science and tactics thus acquired, the system aids directly and powerfully in the formation of those habits of order, regularity, precision, personal bearing, self respect, promptness of execution, the considerate yet energetic exercise of authority upon which a successful career so much depends.

Dr. Benedict is well known to the educators of the State as a successful teacher and administrator. Since the practical cutting off of the Preparatory Department, two years ago, the Sub-Freshman class has naturally come to serve the double purpose of fur-

nishing opportunity for a year of preliminary training to students not fully prepared for the Freshman class, and at the same time of giving those who, on trial, are found unprepared to carry the entire Freshman work, a chance to bring up their special deficiencies without necessarily breaking their whole course. While the subjects taught in that class are directly correlated to the corresponding branches of the College work proper and are, in each case, under the charge of the corresponding heads of College Departments, the entire work of the class is unified and invigorated and directed by the officer immediately in charge. The Trustees rightly felt that this was one of the most difficult and important positions in the Institution, and I am gratified to be able to report that their expectations in the appointment of Dr. Benedict have thus far been fully justified.

The College was also fortunate in securing the services of Dr. Newton as Physical Director. Besides being a thoroughly trained physician he has been intimately associated with athletics during his entire collegiate and professional course, and there is every reason to hope that under his direction this important branch of training will be raised to its proper standard as a means of promoting the development of a complete physical manhood.

Reference to the accompanying reports of professors will present to the Board satisfactory evidence of the vigor and intelligence with which the work of the leading departments of the College has been carried forward during the past year. There is of necessity a considerable diversity in the facilities for instruction possessed by different departments, but it has seemed wisest to provide well for the courses which are sought by the great majority of students, adding to the equipment of others successively as means will allow, rather than undertake an equal or even a proportionate distribution of inadequate appropriations among all. While this policy necessarily requires patience and forbearance on the part of those responsible for certain branches of our work, it enables us to provide well for a few departments and to offer advantages for instruction in them which are entirely adequate for a high range of undergraduate work.

The attendance of students during the last year has shown the same steady increase as for several years past in the College courses, though the dropping of the lower preparatory class (involving a loss of from thirty to forty students) reduced the total for the year to 344 as compared with 346 for the preceding year.

The following tabulated statement presents in a summary view the changes made, year by year, in respect to courses of study, number of members of the teaching force, number of students, college and preparatory, number of counties represented by students, and the courses of study selected by them. The teaching force is shown

in three groups, the first including all professors, the second assistant professors, and the third all of lower rank, as instructors, assistants, etc.:

Summary of the Years 1882-3 to 1895-6.

(Years begin July 1, and end June 30.)

	82-3.	83-4.	84-5.	85-6.	86-7.	87-8.	88-9.	89-90.	90-1.	91-2.	92-3.	93-4.	94-5.	95-6.
Professors,	11	11	11	10	11	12	12	13	16	16	18	16	20	18
Asisstant Professors,	1	1	...	1	...	...	...	1	2	2	5	10	7	11
Instructors and assistants,	5	5	4	5	5	5	7	9	10	12	15	14	16	22
College students,	37	54	60	60	84	92	113	115	127	153	179	181	203	232
Preparatory and special students,	55	71	54	57	66	83	82	90	93	91	108	136	143	112
Total in attendance,	92	125	114	117	150	175	195	205	210	244	287	317	346	344
Counties represented by students in attendance,	22	27	23	23	25	30	32	38	37	42	46	50	50	54
Other States and foreign countries represented,	3	10	14	5	10	13	9	17	19	14	9	8	11	10
Courses elected by College Students.														
General Science,	16	28	23	30	32	19	20	19	21	19	20	19	16	20
Latin Scientific,	...	6	5	12	14	18	28	21	17	7	8	9	7	8
Classical,	8	7	3	(c)	...	...	...	...	..	...	...	...	...	...
Agriculture,	...	...	3	4	2	4	3	3	3	5	1	1	...	7
Chemistry and Physics,	2	4	6	1	...	2(a)	1	...	...	...	...	...	...	...
Chemistry,	...	...	...	...	...	1	...	6	11	22	19	15	11	22
Physics and Electrical Engineering,	...	...	...	...	...	...	10	11	17	22	(e)40	1	...	...
Electrical Engineering,	...	...	...	...	...	...	...	...	...	...	...	57	63	64
Mechanical Engineering,	...	...	...	...	10	18	22	21	19	35	44	44	47	45
Civil Engineering,	6	3	4	1	5	15	17	28	37	37	38	18	29	34
Natural History,	...	1	...	...	1	2	2	...	(b)	...	...	...	...	...
Biology,	...	...	...	...	...	...	...	...	...	1	1	7	9	7
Mining Engineering,	...	...	...	...	...	...	...	...	...	...	...	9	22	23
Ladies' Course (2 years),	...	...	8	6	4	2	...	...	...	1(c)	...	...	...	...
Mechanic Arts (3 years),	...	...	...	2	6	...	1	1	...	...	1	...	...	...
Mathematics,	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Unclassified,	5	5	8	6	10	11	9	5	2	8(d)	7	1	6	...

(a) Course sub-divided into the two following.
(b) Course changed to the one following.
(c) Course dropped.
(d) Mostly in special courses in Agriculture.
(e) Course sub-divided by detaching Electrical Engineering.

The number of students seeking other than technical courses is slowly but steadily increasing, and, what is far more significant and promising, the interest in non-technical subjects is more and more manifesting itself among the great body of students without reference to the specific courses which they themselves are pursuing. The steady strengthening of the courses of instruction in language and literature which has been going on for the last few years is producing most marked and gratifying results. Some of these branches are made a part of the required work of all students, whatever course of study they select, and the results show themselves, not only in a greater skill and facility with which technical students acquire a knowledge of their subjects, but even more in their increased power of ready, exact and effective statement. It is gratifying to note, also, that the taste for literary, philosophical and historical subjects is expressing itself in the formation of voluntary associations and classes for the study of these branches.

The rapid increase of scientific knowledge and of its manifold applications in the industries of life makes increasing demands upon every branch of technical education, thus accentuating that tendency to specialization which is necessarily involved in the nature of the subjects themselves. The danger of technical education is, accordingly, that it will become too narrow, and thus react injuriously upon the whole training and character of the student as a man, at the same time that, in the great majority of cases, it limits his capacity for high advancement even as a specialist. In all its courses the College endeavors to emphasize the distinction between technical studies as a preparation for a trade or profession on the one hand, and, on the other hand, as an education. The combination between theory and practice is made as close as possible, but always, primarily, for the sake of the theoretical principle. The laboratory method of instruction, which is so fruitful in modern education, involves the danger of leading the practical mind to look upon the practical side of knowledge as the more important one. Ultimately that is the true view, since the proper end of knowledge is to serve the uses of man; but there can be no great or permanent advance in practical knowledge except as it is preceded and guided at every step by a knowledge of theoretical principles. All systems of liberal education must be based upon this fundamental truth. The student whose training is to give him power must acquire a firm and sure grasp of principles. Laboratory manipulations are good and useful in proportion as they serve to fix attention upon and define the applications of such principles. That the laboratory furnishes a direct and valuable preparation for the practice of a profession is, indeed, one of its great advantages; but it is only a single

advantage and that by no means the most important one. The most serious problem, therefore, of technical education *as* education is to find the proper balance and adjustment between theoretical training and practical training, as to both the kind and the extent of each. In view of the pressing demands for time for strictly technical work, it is increasingly difficult to find room for other liberalizing and broadening studies; but if the technically trained man is to hold his own in the larger competitions of modern life, especially under the system of public institutions existing in the United States, opportunity must, in some way, be found to give the student during his course of undergraduate study some acquaintance with those outlying fields of knowledge and research.

The true solution of the problem will be found, I believe, in a certain recasting of prevailing conceptions as to the nature and orderly sequence of technical studies and their necessary correlation with other branches of learning, and with the natural development of the mental powers.

The first step in this direction must be a strengthening of the courses preparatory to college and that, in turn, since the preparatory work is coming to be done more and more by the public schools, requires a strengthening of the work of these schools with reference to this specific end. It is often remarked, and truthfully, that the primary object of the public schools is not to prepare young men and young women for college, but for the work of life upon which they must early enter. But a thorough elementary training, carried on according to the natural order of studies, which means the order of their adaptation to the developing powers of the mind, will be found equally advantageous to those who do and those who do not expect to enter college walls. No elementary education can be too good for those who are to enter on the duties of citizenship, in whatever walk of life, and if the foundations are thoroughly laid in the elements of language, literature, history, mathematics and science, the student who leaves school at that point has, at least, such training as will steady his judgment and such instincts of inquiry as will guide his way to the acquisition of later knowledge throughout the course of his active life. On the other hand, the student who expects to pursue a college course will have laid the indispensable foundations for it in such a course of training. With the widening area of public thought and public activity respecting great social problems, the importance of which become every year more pressing, the field of public school instruction must be correspondingly widened and deepened, if it is to prepare the great body of citizens for their duties in this age, as well proportionately as was done by the simpler and more elementary systems of education in years gone by. But, as I have already indicated,

whatever advancement is made in this direction serves both to furnish the incentive and to provide the means for entering upon more advanced courses of study. In this way, then, I look to see the question of technical education simplified by having its foundations more broadly and securely laid and a portion of its first stages completed in the public schools.

The second step in the revision of systems of technical education must be a more clearly defined line of demarcation between studies appropriate to an undergraduate college course and those which belong more properly to university or graduate courses. The old distinction between preparatory, collegiate and professional courses need not probably be strictly followed, though it has its manifest advantages. But if there is to be a merging of any two of these stages it is far better, in my judgment, that the secondary and collegiate courses should be made strictly continuous than that the distinction between collegiate and university studies should be obscured. If greater thoroughness of prepraation for college work can be secured, it should not be difficult to compress the necessary work of a college course into three years; for I believe it is within the limits of fact to say that more than nine-tenths of the colleges and of the so-called universities in the United States are obliged to spend fully one year of their time in doing work which ought to be done in the preparatory school. But whether the college course be three years or four years—or less or more than either—no system of education can produce the best results, or results worthy of the name of a liberal education, which does not set aside a somewhat lengthened and closely connected period of training during which the leading objects shall be to make the student systematically acquainted with the elementary principles of the great departments of human knowledge, to guide his mind by natural and well ordered steps in the acquisition of that knowledge, and so to discipline his mental powers that the systematic, well-balanced and logical exercise of them comes to be, by continuous and reiterated practice, the necessary and almost mechanical intellectual habit.

The difficulties of enforcing such a period of training—great in any case—are greatest in a course of technical education. After young men have completed the preparatory stage, they are, in general, at a period of life when the impulses and choices and powers of young manhood are first asserting themselves, while the experience of life has not yet been sufficient to furnish the necessary check and counterpoise. It is inevitable, at such a stage of experience, that young men who are looking forward to an active professional career should become impatient even of necessary restraints, should be inclined to slight and undervalue studies which do not seem to them to prepare directly for their chosen work, and eager to bestow all their time and attention upon subjects which

appear to furnish a short cut to the end they have in view. Technical studies, and all in which laboratory methods are largely employed, tend to increase this manner of looking at things, for the reason that they introduce the student, almost from the first steps into the kinds of investigation and of practical processes which form a part of the work to which he expects to devote his life. The college, accordingly, needs to guard itself against laying undue stress upon the practical, or experimental side, of technical teaching, in order to make sure of the most thorough possible grounding in and familiarity with fundamental principles. In other words, it is the function of the college, as I understand it, to make the student acquainted with the instruments of his profession, and to teach him skill and precision in using them, so that he may enter with the powers and the confidence of a trained intellectual athlete upon the arena of actual experience. If he then desires to specialize his work, or to pursue some line of original research, the university should offer him the requisite facilities.

On the other hand, an institution which fails to mark the distinction between collegiate and university methods, and under the shadow of a name deludes its students with the idea that they are doing real university work while they are only taking the first uncertain steps in the acquisition of knowledge and require the steadying lead of a well-regulated curriculum, instead of the freedom which a true university provides, does a wrong to the student himself, and a most serious injury to the cause of sound education.

I have discussed the topic at some length, not for the sake of maintaining any theory, however, important it may be, but, specifically, for the purpose of calling attention to the relation between the State College and the public school system of the State, and to the conditions which are essential to the best work of both. The College for a few years past has drawn students from fifty or more counties of the State, a large proportion of whom have received their preparatory training in the public schools; in some instances this training has been of excellent quality, but, a considerable number come to us every year whose preparatary work, through no fault of their own, has not fitted them to carry successfully the studies of the Freshman year. Even in cases where they have nominally gone over the subjects required for admission they have been found untrained in habits of thought and expression, and not sufficiently familiarized with elementary principles to be tble to use them readily in college work. Successive classes give evidence of improvement in this respect, and there is good reason to believe that a much greater improvement will soon become apparent if the Legislature of the State shall make provision for township high schools, as recommended by the State Superintendent of Public

Instruction. In the meantime the State College has incurred unfavorable criticism in some quarters on the ground that its standard of admission, and of requirements after admission, was too high for the average student. To admit that would be to say that the average Pennsylvania boy or girl is not capable of doing a grade of work which is done habitually and easily by the youth of our sister states, and there is no ground for such an admission. Nor is there any ground for believing that our public schools cannot do efficiently the kind and quality of work that is done by similar schools elsewhere. The State contributes liberally, not to say lavishly, to the support of its schools. What we need is an educational revival, an awakened and imperative public sentiment demanding that this money shall be so used as to produce results commensurate to the expenditure. It is a source of great gratification to find each year an increasing number of schools so directing their courses of study as to prepare students well for admission to the State College, and the College has felt, in turn, that its support by the State could only be justified by the maintenance of such a standard of work as would continue to stimulate and aid the public schools, and, at the same time, send its graduates to the work of life trained and equipped with the powers of a well-rounded manhood and womanhood. The College is justly proud of the careers of its graduates, who easily sustain themselves in competition with the graduates of the best institutions elsewhere, and a number of whom give promise of high distinction. Pennsylvania has hosts of young men who have equal ability with these, if once their ambition is stirred by the stimulus of suitable educational advantages in their own neighborhood. Such youth are the hope of the Commonwealth, and if Pennsylvania is to hold among the states of the Union that leadership to which the wealth of her natural resources, the vastness of her industrial interests, and the energy and intelligence of her people entitle her, she must look well to her system of public education, both the higher and the lower. As the late Jules Simon well said, when speaking of the competition of modern times: "The best educated people will be the winning people." It has seemed possible that the College might render some direct service to the teachers of the State, by throwing open its laboratories and other facilities for special instruction or research during a portion of the summer vacation. The Executive Committee of the Trustees and the Faculty, after giving the subject long and careful consideration, are agreed that the time has come to make a beginning in that direction, and the Faculty at its last meeting unanimously adoped a recommendation to the Board which will be presented for action at this meeting. The plan adopted has my hearty approval, and I hope it may receive the sanction of the Board.

There is one other relation which the College is coming to occupy towards the people of the State, of a peculiarly interesting and important kind. The work of its Agricultural Department is awakening the interest of a rapidly increasing number of people, and is rendering to that great branch of industry a variety of services which are coming to be widely recognized and appreciated. The demand for the bulletins and for the annual reports of the Experiment Station exceeds by several thousand the number available for distribution. Within the last three months, no less than fourteen hundred requests have been received at the Station, most of which could not be complied with. The "Chautauqua Course of Home Reading" and the Short Winter Courses in Agriculture all have an increased enrollment during the present year, and it was necessary to refuse admission to a considerable number of applicants for the Creamerymen's Course, because of the lack of room in the dairy building to accommodate them.

A similar demand for service is made upon the Mining and Chemical and Botanical laboratories. The report of Professor Ihlseng shows that during the past year eighty-three examinations and determinations of minerals have been made by the Mining Department, in answer to inquiries bearing directly upon the development of the resources of the State. Similar reports are made by Professors Buckhout and Pond for the Botanical and Chemical laboratories. If a small sum could be set aside for such work, it would enable these and other laboratories connected with the College greatly to increase their usefulness to the public, without interfering with their use by students.

The special report on the brown stones of the State, prepared by Assistant Professor Hopkins, of the Mining Department, will be found to be an important contribution to our knowledge of one branch of the natural resources of the State, and an indication of one of the many directions in which the usefulness of the College to the public is making itself felt. I do not attempt in this report to make even the slightest summary of the exhibit presented in the reports of the several departments as to their respective work and needs. I respectfully commend them to the careful consideration of the Board of Trustees.

The experience of each year increases my own sense of the importance of the field occupied by the State College, and the growing demands upon it present a constantly widening view of its vast possibilities. With this I find a continually deepening sense of responsibility as well as of hopefulness for the future, and I desire again to express my sincere appreciation of the cordial support and helpfulness manifested by students, faculty and trustees.

Respectfully submitted,

January 27, 1897. GEO. W. ATHERTON.

I.—AGRICULTURE.

A—THE EXPERIMENT STATION; B—AGRICULTURE; C—AGRICULTURAL CHEMISTRY.

A. EXPERIMENT STATION.

To the President:

Sir:—The work of the Experiment Station during 1896 has been continued along substantially the same lines as in previous years and but few changes have been made in the personnel. Mr. M. S. McDowell, assistant chemist, tendered his resignation on Sept. 7th to accept a more lucrative position elsewhere. Mr. C. A. Browne, Jr., was appointed to the vacancy thus occasioned and later Mr. C. W. Norris was employed temporarily as assistant chemist, additional assistance in this department being required to perform promptly the work of fertilizer and food analysis.

An enumeration of the various experiments which have been in progress during the year would be so largely a repetition of previous reports that, in place of this, I desire to present some considerations regarding the main features of the work of the Station and their possible development, referring to the detailed papers accompanying this report for specific information regarding the work accomplished.

Tobacco Experiments.—As stated in my last annual report, a bill renewing the special appropriation for these experiments was passed by the Legislature of 1895 but was vetoed by the Governor. In order to prevent a lapse of the experiments and the consequent practical loss of much of the work already done, the State Department of Agriculture offered to defray the expenses of the work from its fund for special investigations. Under this arrangement, work has been carried on in Lancaster and Bradford counties. One set of plots in Lancaster county, namely, that at Rocky Spring Park, had to be abandoned owing to a change in the management and the unwillingness of the lessee to continue the arrangement. It was not deemed wise under the circumstances to attempt to secure another location and work in that county has consequently been confined to the location at Donegal on the farm of the Hon. J. Donald Cameron, to whom, as well as to his manager, Mr. A. C. Rutherford, we are under obligations for opportunity to continue these experiments for several years in the same locality. In Bradford county, owing to similar causes, it became necessary to re-locate the ex-

periments, which are now being carried on upon the farm of the Hon. Louis Piollet at Wysox.

The work has been upon the same general lines as heretofore and, in addition, some tests of varieties of tobacco have been made which promise interesting results. The experiments with fertilizers have been directed primarily to the production of a leaf of high quality for wrapper purposes, the question of quantity being secondary. The curing experiments with artificial heat have also been continued at Donegal with most satisfactory and promising results. At the same time both the use of fertilizers and artificial curing need further and continuous investigation. Since the inauguration of the experiments we have had but one good tobacco season, namely, that of 1896, and the season, as is well known, is a very important factor in determining the quality of the tobacco crop. Moreover, the tests with fertilizers should be continued for a series of years in order to demonstrate the effects of their continuous use. The matter of curing by artificial heat, which enables the grower to control the conditions, is still in its infancy and while very promising has hardly yet reached the stage of being an assured commercial success. It would be very desirable also to make experiments upon the lighter soils of northern Lancaster county and likewise to investigate the question of irrigation as applied to tobacco.

Work of this character, to be of permanent value, and worth the money expended upon it, should be done in a scientific manner and carefully checked at all points by laboratory tests. At the same time, however, it needs for its successful prosecution the widest practical experience in the growing and handling of the crop. The experiments were therefore wisely made co-operative, enlisting the scientific resources of the Experiment Station on the one hand and the practical experience of the organizations of tobacco growers on the other. I earnestly hope that the coming Legislature will take such action as may seem wise looking toward a continuance of these valuable and interesting experiments.

Soils and Fertilizers.—The analysis of commercial fertilizers in connection with the control of the fertilizer trade exercised by the Department of Agriculture has now been performed by the Station for eight years. This combined work of the Department and the Station is of the utmost value in informing farmers as to the quality and value of fertilizers sold in the State and in preventing fraudulent practices. Notwithstanding all this, however, there is no question that much money is wasted in the purchase of commercial fertilizers. The Secretary of Agriculture estimates that the farmers of Pennsylvania spend about $3,750,000 yearly for fertilizers, of which fully one-fourth is virtually thrown away. Un-

doubtedly a portion of this enormous waste arises from general ignorance as to the use of fertilizers but very much of it is also due to lack of acquaintance with the specific needs of soils and crops. A good illustration of the importance of this matter is given by the experiments reported in Bulletin No. 35 of this Station, in which it is shown that the intelligent as compared with the unintelligent use of fertilizers increased the profits of the potato crop fully $50 per acre.

This knowledge was acquired in this particular instance by means of a comparatively simple soil test made by the farmer himself. But while, in exceptional instances, farmers may experiment, it may be accepted as a fact that such work will not usually be done successfully. To most busy farmers, the conduct of a field test with fertilizers appears like an impossible task and particularly is this true of farmers upon the newer and rougher lands of the State where knowledge of this sort would be particularly valuable. There is need for a broad, general study of the soils of the State; their chemical, physical and agricultural properties and their specific needs for fertilizers. Such a study would do much to prevent the great economic loss mentioned above and would furnish information of the utmost value to the intelligent farmer. Such investigations would seem particularly in place in those sections of the State which are practically just beginning to be occupied for agricultural purposes. A soil survey of this sort might save the farmers of these sections long and costly efforts to grow crops not adapted to their soil and locality or, on the other hand, might help them to fertilize and handle soil and crop to best advantage. The Experiment Station has done work of this sort on its own grounds but has not been in position to go further. I earnestly hope that means may be provided to enable us largely to extend this branch of our work.

Horticulture —Hitherto the horticultural work of the Station has been confined largely to variety tests of vegetables and fruits. With the opening of the last season, however, this policy was changed. The testing of garden vegetables was dropped entirely and that of small fruits confined to varieties not on the market together with a few standard varieties grown for comparison. In lieu of the work thus dropped, an investigation of fruit growing in the State has been begun, the peach being selected as the first object of study. The Horticulturist of the Station has visited growers, nurserymen and marketmen in various sections of the State and I beg to refer to his report, printed as Bulletin No. 37 of the Station, for details.

This appears to me to be a very important line of work. As a result of the present agricultural depression, farmers generally are looking for new crops better adapted to the present conditions

than the staples, and which may bring them large returns. Large sections of this State can grow fruit and the general interest in this subject is increasing. The Station can render important aid to those contemplating embarking in this industry by furnishing them information like that contained in Bulletin No. 37. Moreover, the numerous problems which beset those already engaged in the business are such as call for the best aid which science can offer for their solution. A study of present conditions like the one already undertaken should be followed by experimental work both local and general. Furthermore, the market-gardening and horticultural interests near the large cities are of great importance and as yet we have not been able to do any considerable amount of work in their aid.

In order properly to occupy this extensive field, the Station should have largely increased funds to devote to this subject. The neighboring State of New York is now appropriating annually $24,000 for special investigations in horticulture, and under the efficient management of her two experiment stations is powerfully aiding and building up the horticultural interests of the State. While these interests in Pennsylvania are relatively less important than in New York, yet, owing to this very fact, they call all the more loudly for aid in developing this very promising branch of agriculture

Dairy Feeding and Dairying—These two correlated subjects have constituted the main line of Station activity. Their present importance and prospective greater importance fully justify this choice. World-wide competition in the production of staples, especially breadstuffs, is forcing farmers into other lines. For those who are fitted for it, both in themselves and their surroundings, the production of fine dairy goods is one of the important directions in which relief may be sought. Major Henry E. Alvord, Chief of the Dairy Division of the U. S. Department of Agriculture, in a recent address states that, "A can of milk, box of cheese or tub of butter have a purchasing power to-day more nearly that of the good old times people so often refer to than has either a bushel of wheat, a barrel of flour, a carcass of beef or pork, a bale of cotton or a cask of tobacco. This relative position gives to dairying a leading place which should be held. And, if the reforms and improvements can be measureably attained by our dairying interests, it will maintain its place as the most profitable and most intellect-stimulating branch of agriculture."

In the prosecution of the dairy industry, however, perhaps even more than in most other branches of farming, special knowledge and skill are requisite to attain the highest success. For aid in attaining this knowledge, the dairymen of the State naturally look

to the Agricultural College and Experiment Station. Accordingly a large share of the attention of the Station has been given to the subjects of the building up of the dairy herd, the profitable feeding of dairy cows, and the manufacture of butter and cheese.

As regards the technology of dairying, our activity has been largely in educational lines, dairy courses having been successfully carried on for the past four years. In addition to the work of instruction, however, the Experiment Station has made somewhat extensive tests of dairy machinery, has made some experiments in the manufacture of domestic cheese, and has made arrangements for supplying correctly graduated testing apparatus to creamerymen.

In the improvement of its own dairy herd, the Station has aimed to exemplify those principles which should control the dairyman in the pursuit of the same object. Beginning in 1889 with comparatively poor stock, the Station has, without any extravagant expenditures for fancy animals, graded up its herd until its production now averages about 350 lbs. of butter per year. A bulletin giving the details of the methods pursued and the averages of the herd for successive years is now in preparation.

Our experiments in dairy feeding have included a study of forage crops, their cultivation, yield, and the methods of preserving them; the soiling questions; and the economic feeding of dairy cows as to amount and quality of ration.

The work of the Station on forage crops and upon the soiling system was quite fully summarized in my annual report for 1894. For the past three years, our main line of experiment in this direction has been a study of the relations which exist between the amount and composition of the food and the yield of milk and butter, particularly with reference to financial results. Notwithstanding the large number of feeding experiments with dairy cows which are on record, but little attention has been given directly to this point. The majority of feeding experiments are comparisons of different feeds rather than a direct study of the relations of feed to product. They have given results of the greatest value but not results which are very directly applicable to this question. Plainly, however, until we know fully what disposition the animal makes of the several constituents of its food and how this disposition is affected by the amount and composition of the food itself, by the individuality of the animal, and by the external conditions, we are not in a position to use feeding stuffs with a full degree of intelligence. The subject is a broad one and while some of its aspects seem remote from practical utility yet, ultimately, they are matters of great practical importance to the dairyman. It is proposed, with the approval of the Board, to continue work along these general lines. In other words, it is proposed that the Station shall en-

deavor to become, as far as possible, by exhaustive study and experiment, an authority upon dairying and dairy feeding in all their aspects for the benefit of the dairymen of Pennsylvania.

Grouping of Work.—With the above suggestions carried out, the work of the Station would group itself about three main lines:

1. Soils and fertilizers, including the fertilizer analysis, the special tobacco experiments and the soil survey.

2. Horticulture, including such variety work as seems desirable but paying special attention to the subject of fruit-growing in the State.

3. Dairy husbandry, including dairy feeding and the manufacture of dairy products.

These three main lines of work are far from covering all the aspects of agriculture in the Commonwealth and it would be very easy to suggest important additional lines of work. An Experiment Station, however, is usually in danger of undertaking work in too many rather than in too few directions and it should be our policy to concentrate our efforts rather than to dissipate our energies upon many subjects. For the present, it will be the aim of the Station to strengthen these main lines of work, adding new subjects only as adequate funds can be secured.

State Aid.—Some of the suggestions made above look in the direction of State aid to the Experiment Station. It may be proper therefore to append a statement of what the State has already done in this direction. The appropriations by the State for the Experiment Station have been as follows:

Legislature of 1887, ...	$12,000
Legislature of 1889, ...	7,000
Legislature of 1893, ...	4,000
Total, ...	$23,000

Of these, the appropriation of 1887, which was distributed over four years, was employed in the erection of the present Station building. The appropriation of 1889 was a special appropriation for the enlargement of the farm buildings, and that of 1893 was the appropriation for co-operative tobacco experiments not located at the College. There has been no direct appropriation by the State for the current work of the Station. Its income is derived entirely from the United States fund (Hatch fund), what it earns in fees for the analysis of fertilizers and foods, and the sales from the Station farm.

It can hardly be assumed that Congress, in providing national support for the Experiment Stations, intended to relieve the several States of all responsibility for the development of their own agri-

culture and the study of their own special problems. As a matter of fact many of the States are adding largely from their own funds to the United States appropriation. In 1894, the last year for which I have complete statistics, there were thirteen States whose Station or Stations received a total income of over $20,000. In these States, the percentage of the total income derived from the United States fund, from State funds, from fees and from other sources, was as follows:

	Total income.	Percentages Derived from			
		United States appropriation.	State appropriation.	Fees.	Sundries.
California,	$23,000 00	65.22	34.78		
Connecticut (two stations),	29,053 68	51.62	27.54	19.40	1.44
Louisiana,	58,150 00	39.32	38.01	9.83	13.24
Massachusetts (two stations),	29,623 37	50.64	33.76	10.13	5.47
Minnesota,	27,383 27	54.38	45.62		
Montana,	23,000 00	65.22			*34.78
New Jersey (two stations),	26,000 00	57.70	42.30		
New York (two stations),	74,792 76	20 05	78.88		1.07
North Carolina,	23,665 82	63.38	33 80		2.82
Ohio,	43,480 41	34.50	41.63		23.87
Pennsylvania,	28,925 25	51 86	†5.19	37.16	5.79
West Virginia,	24,445 50	61.36			38.64
Wisconsin,	25,450 00	58.94	21.42		19.64

*From individuals and communities. †Special appropriation for tobacco experiments.

Excluding the figures for West Virginia on account of the abnormally large amount received from sales of farm products, the other eleven states show the following average as compared with Pennsylvania:

	Total income.	Percentages Derived from			
		United States appropriation.	State appropriation.	Fees.	Sundries.
Average of eleven states,	33,072.66	45.36 per cent.	42.51 per cent.	3.40 per cent.	8.74 per c't.
Pennsylvania,	28,925.25	51.86 per cent.	5.19 per cent.	37.16 per cent.	5.79 per c't.

It thus appears that in these eleven States the average annual income in 1894 was about $1,000 greater than in Pennsylvania, that of this greater income 42½ per cent. was derived from the State as compared with a little over 5 per cent. in Pennsylvania, and that even this latter small proportion was for a specific line of co-operative work. On the other hand, in these eleven States, 3.4 per cent. of the average income was derived from fees, while the Pennsylvania Station earned over 37 per cent. of its income in this way.

Making the same comparison with the three neighboring States of New Jersey, New York and Ohio, we have the following figures:

	Total income	Percentages Derived from			
		United States appropriation.	State appropriation.	Fees.	Sundries.
Average of New Jersey, New York and Ohio,	48,091 06	31.19 per cent.	67 07 per cent.	. . . . .	7.74 per cent.
Pennsylvania, ...	28,925 25	51.86 per cent.	5.19 per cent.	37.16 per cent.	5.79 per cent.

In these three States, the average amount expended upon Agricultural Experiment Stations annually was about $9,000 greater than in Pennsylvania. Of this larger amount, the State furnished 67 per cent. as against 5 per cent. in Pennsylvania, while the Pennsylvania Station earned 37 per cent. of its income in the form of fees as against nothing in the case of the other three States. As compared then with neighboring States or with the larger Stations throughout the country, it is evident that the income of our own Station is considerably smaller, that a disproportionate amount of its income is derived from fees, and that the State's contribution is relatively very small. In view of these facts, the suggestion above made, of special appropriations for a study of the soils of the State and of the fruit-growing industry, do not seem out of place or extravagant.

The School of Agriculture.

To an even greater extent than in previous years, the work of instruction in agriculture to be done has exceeded the means available for doing it.

The Short Winter Courses, especially the Creamery Course, have been, as before, the popular feature of our educational work. For the present winter, thirty-nine have been enrolled in the Creamery Course and several applicants were refused on account of lack of accommodations in the creamery. Two of these have already registered for 1898. Th Short Course students number thirteen with two additional names registered for the private Dairy Course beginning in February. The following summary, in which some errors in the report of 1895 have been corrected, shows the number in attendance upon these courses during the past six years and indicates their geographical distribution:

Number of Students.

	Creamery course.	Short course and private dairy course.	Total.
1892, ...	. . . . .	4	4
1893, ...	15	6	21
1894, ...	23	13	36
1895, ...	37	15	52
1896, ...	14	9	23
1897, ...	39	*15	54
Total, ...	128	63	190
Counties represented, ...	42	27	50
States other than Pennsylvania represented, .	2	6	7

*Including two registered for private dairy course.

It should perhaps be added in explanation of the falling off in numbers in 1896, that, owing to Professor Waters' resignation and to some necessary delay in securing his successor, the courses of that year were not as well advertised as usual.

Our present accommodations for both these courses, but especially for the Creamery Course, are lamentably insufficient. The numbers in the Creamery Course have reached the limit of our accommodations and indeed already exceed the limits of satisfactory instruction. Moreover, with our present insufficient quarters, it is impossible to give any instruction whatever in cheese-making. We urgently need a dairy building fitted up with the best modern appliances for both butter and cheese-making. Plans for such a building have been prepared and I earnestly hope that it may prove feasible to erect the building at an early day.

The number of students in the Collegiate Course continues to increase, there being now four juniors, six sophomores and three freshmen in this Course. There is a not inconsiderable and growing demand for thoroughly educated young men as managers of estates, as instructors in Agricultural Colleges and as assistants in Experiment Stations. While the number in this Course is still small, the gradual increase may perhaps be taken as indicating a growing realization that agriculture offers as good an opportunity for the investment of capital and intelligence as any other legitimate business. While I do not anticipate any very rapid increase at present, I believe that we may reasonably look for some further growth in this direction and in support of this it may be mentioned that we have reports of several young men in different parts of the State who are contemplating taking this course.

In addition to its work at the College, the School of Agriculture has done more than in any previous year to meet the demands of those outside its walls for information and instruction. This is a very important and perhaps, in the present state of agricultural education, the most important part of its work. At the request of the Director of Farmers' Institutes, representatives of the School were detailed to accompany the three sections into which the institute workers of the State were divided. These gentlemen are attending all the institutes held in the State, presenting especially the work of the Chautauqua Course of Home Study but incidentally also the other Agricultural work of the College. The results of this have been very satisfaatory. Considerable numbers of farmers have been enrolled in the course of home study and very many more have been reached personally and made acquainted with the work that the College and Station are doing for them. As a result, very many letters of inquiry are being received and fully 1,500 requests for

the publications of the Station have been received within the last four months.

As another means in the same direction, in pursuance of a recommendation contained in my report of last year and approved by the Board, the first of a series of Bulletins of Information has been prepared and distributed at the farmers' institutes and to the mailing list of the Station. This bulletin was entitled "Computation of Rations for Farm Animals." It is hoped that it will prove feasible to follow it with others upon various aspects of agriculture. In my judgment, this general line of work is a very important one and I venture to repeat from my report of last year that the special demand of the farmer at present is for information regarding what is known of the principles of agriculture rather than for special investigations in particular directions. I believe the publication of bulletins of information should be continued, that the work of the Chautauqua Course should be pushed, and that if possible provision should be made for aiding the students in this latter course by means of lectures substantially upon the University Extension plan.

Agriculture is one of the greatest producing industries of the Commonwealth and both on this ground and for the reason that any improvements in agriculture tend to benefit consumers as well as producers of agricultural products, it is entitled to full consideration at the hands of the State. At the present time, too, owing to the sharp competition of other countries and the resulting depression in farming, there is a special need for better technical education for the farmer. The School of Agriculture of the State College is the recognized and official agency of the State for supplying systematic, technical training in this subject and it is endeavoring to fulfill this trust as well as the somewhat limited means at its command permit. During the past six years, the appropriations made by the State for agricultural education, including the work of the farmers' institutes, and for the Experiment Station, have been as follows:

Appropriations Per Year.

	1891-2.	1893-4.	1895-6.	Average.
Agricultural Education:				
Institutes	$8,500	$11,500	$7,500	$9,167
School of agriculture	.....	2,000	5,000	2,323
	$8,500	$13,500	$12,500	$11,500
Agricultural experiment station	.....	2,000	.....	667

In other words, the Commonwealth of Pennsylvania for the past

six years has been appropriating yearly to the School of Agriculture and the Agricultural Experiment Station at the following rate:

Average Per Year.

	Farmers' Institutes.	School of Agriculture.	Experiment Station.
For each farm in the State	4.3 cents.	1.1 cents.	0.3 cents.
For each 100 acres improved land	7.1 cents.	1.8 cents.	0.5 cents.
Per $1,000 gross agricultural product	7.5 cents.	1.9 cents.	0.6 cents.
Per $1,000 agricultural valuation	0.8 cents.	0.2 cents.	0.06 cents.

That is, if the amounts appropriated for these purposes had been paid exclusively by a tax levied on the agricultural valuation of the State, instead of upon its total valuation, that tax would have amounted, for the School of Agriculture, to two one-thousands of a mill, and for the Agricultural Experiment Station to six ten-thousandths of a mill.

In view of the above figures, it may fairly be said that, in proportion to her wealth and her agricultural resources, Pennsylvania has been making comparatively small appropriations to agricultural education. I believe that the importance of agriculture to the State is great enough, and that the work of the School of Agriculture and Experiment Station has sufficiently shown its value, to justify more liberal appropriations and I trust the day is not far distant when at least our most urgent needs may be provided for.

In conclusion, I beg to acknowledge most gratefully the constant support and encouragement received from yourself and the Board of Trustees and to express my appreciation also of the earnest and devoted work which has been done by all members of the Station and the School.

Respectfully submitted,

H. P. ARMSBY,
Director.

State College Pa., January 25, 1897.

B.—AGRICULTURE.

To the President:

Sir:—I have the honor to present herewith the report of the Agricultural Department.

In general, the work inaugurated in previous years has been continued along the lines previously followed. While new lines of investigation have been commenced, yet they have been taken up in such a manner as to avoid interference with well matured plans of investigation already established.

In instructional work many profitable changes have been made possible through additional appliances recently secured.

The equipment of the Department for both experimental and educational work has been materially increased during the past year. The purchase of pure bred horses, cattle, swine and poultry makes it possible to give instruction in Animal Industry that could not be attempted in former years.

A span of Clydesdale brood mares serve an admirable purpose in illustrating to our students the type of heavy draft horses. Means have been taken for perpetuating the herd of Short Horn cattle owned by the College. Young animals of pure bred swine that have recently been purchased form a valuable addition to the educational equipment of the Department.

A new poultry house with additional breeds of pure bred fowls presents an opportunity for giving thorough instruction in certain lines of this most important industry.

Modern methods of rearing fowls for egg production and for the most profitable meat production demand extensive use of machinery which the Department has been obliged to ignore on account of the lack of proper facilities for taking up this most important work.

One of the greatest needs of the Department is the erection of a permanent building for the use of incubators and brooders, which have become as important in the poultry business as are separators and butter workers in the creamery. At the present time there is not an available room that is at all adapted for this purpose.

At present the technical work in agriculture is chiefly given during the Junior and Senior years. While somewhat less time is devoted to this work than formerly, yet the fact that the instruction is given consecutively and all in the latter part of the course, enables the instructors to give work of more advanced character. An addi-

tional year's work in French or German has been introduced which now gives the student who pursues this Course, two years' drill in one of these studies.

The instruction offered to the Short, or Winter Course students has been increased over that offered in previous years.

At present, instruction is offered in more subjects than the student can pursue at one time, which gives them a choice of studies. The increase in the number of students and their general satisfaction with their studies both indicate an appreciation of an optional course on the part of the student.

The Chautauqua Course of Home study in Agriculture is more popular than ever before. The number of students enrolled far exceeds two thousand, with a rapidly increasing list. The recent revision of the list of books in the Course has met a popular demand for more extended study.

Correspondence has clearly shown that some means of aiding the students with their study of the books in the Course should be provided by the College. Partially to meet this growing demand the superintendent has prepared a guide to the study of one of the books used in the Chautauqua Course. If sufficient help is to be given the students in this Course to meet the urgent demands, an assistant should be given the superintendent during the winter term. With the present force it is impossible to develop the work of the Course at the time the students have the most time to devote to study, namely, during the winter months. The number of students enrolled in the Course and the interest taken by them in their work clearly indicate that greater assistance by the College in aiding those who are pursuing systematic study at home will be a potent factor in still further developing the Course and advancing agriculture in the State. The present needs of the Course are chiefly more information of the subject matter contained in the books of the Course and some systematic assistance on the part of the College to aid the student in his effort.

All of which is most respectfully submitted.

G. C. WATSON,
Professor of Agriculture.

State College, Pa., Jan. 1, 1897.

II.--BIOLOGY.

To the President:

Sir:—During the past year substantial progress has been made in the biological work of the College. Facilities have never before been so good, and the work of the students has correspondingly improved.

The Course in Biology is intended to provide for those taking it a well rounded education, and, in addition, to prepare the student for a medical course, for teaching the Natural Sciences, or for advanced professional work in such biological lines as he may select. With this in view, the work of the last two years of the course is intended to be somewhat elastic, in order that a student who has determined the particular line of work he will thereafter pursue, may choose the subjects most closely related to that work. This latitute is the more necessary as Biology is no longer one science but a group of sciences each of which demands specialization from an early period.

For the student who expects to specialize in medicine the facilities provided by the College are unusually good. In Anatomy skeletons, articulated and disarticulated, both of man and of the higher animals are provided, and are in constant use by the students. Prepared specimens of the articulations showing the ligaments in their proper relations; muscles and other prepared material—all are placed in the hands of the student for his personal examination, and book work is replaced as far as possible by the study of the objects themselves. In this way "the danger of the deceptive diagram" is avoided. Where the objects themselves cannot be obtained for use in this way, they are replaced by models, most of which have been imported for this purpose. Dissection is also taken as a part of the work, that the relations and appearance of the various parts of the body and the best methods of exposing them for study may become familiar.

In Histology the microscopic structure of the tissues and organs is considered. Here the lectures are supplemented by the study of the parts under the microscope, drawings of each part being made and explained by each student. The preparation, staining, cutting and mounting of these specimens is also carefully taught, and the equipment for this portion of the work is excellent. Two microtomes, reagents in abundance, and the literature of the subject, are at hand and regularly used. Microscopes of various makes, and with

powers ranging from fifteen to over one thousand diameters in magnification are also provided.

Physiology is treated by lectures continuing through an entire year. The importance of careful training in this subject is evident, and a thorough knowledge is insisted upon. Critical study of the functions of the blood, of circulation, respiration, digestion, absorption, excretion, etc., with constant references to the latest works on these subjects, give to the student that knowledge of the workings of the body which is so much needed to secure their application to the preservation of health. It is hoped that laboratory work in this subject may also soon be provided.

In Embryology the objective method is used, only enough lectures being given to provide the student with a key to the laboratory work which occupies nearly all the time alloted to the subject. Development from the earliest stages through the formation of the different organs is followed step by step, every change being recorded by drawings, the preparation of which fixes these processes in the mind of the student. Models and enlarged drawings are freely used in the course of this work.

Before graduating a graduation thesis is required. Here the student is assigned some subject for special investigation. He is required to make preparations and drawings, and prepare a paper giving the results of his studies, the object being to teach the methods of original research, and of work which cannot be checked at each step by that of others, but where he is in an entirely new field and must work without guidance. The object of this is to fit the student to take up original work later, if he should so desire, without hesitation as to the way in which it should be done.

Some of the theses thus prepared during the last few years are: "The value of trichloracetic acid as a test for albumen;" "Saltpetre as a remedy for the cabbage worm;" "The structure of light and dark meat in fowls, with reference to digestibility;" "The microscopic structure of phosphorescent organs," etc.

General Biology is given to students in several courses. Coming at the beginning of the biological work it includes a study of the structure both of animals and plants, the uses of their various parts, and the relations of all living things to each other and to their inanimate surroundings. It might almost be termed a "birds-eye-view" of life, serving as it does, to provide a general knowledge of plants and animals for those who pursue this line of study no farther, and as an introduction to the more minute scrutiny of these forms for those taking other biological subjects. In this work, models, enlarged drawings and the objects themselves are in constant use, while, in the laboratory, the student learns to use the microscope and scalpel to verify the classroom work, and discovers in addition that his

study is far from exhaustive and that his knowledge is after all only a beginning—often a most valuable lesson in itself.

General Biology is followed by Botany in which subject a more intimate knowledge of the structure and uses of plants is presented by the Professor of Botany. This is followed by Zoology which is treated in a similar manner, examples of each of the main groups being carefully studied both in the lecture room and in the laboratory and, whenever possible, in their natural surroundings as well. Parasitic animals; corals and their influence upon island and continent formation; insects and their relation to man; the domestic animals: all are carefully treated. Frequent excursions are utilized to teach the student how and where to look for different animals and observe the ways in which they adapt themselves to their surroundings. Charts, models and specimens are constantly in use during the study of zoölogy and a well equipped museum is not only a place of interest for visitors, but is serving a still better purpose, nearly every specimen it contains being examined by the student in connection with his work. The State Collection of Birds and Mammals has recently been deposited at the College and is attractively arranged, the habits of each specimen being shown as far as possible by its mounting and surroundings. The utility of such a collection can hardly be overestimated. The work in zoölogy concludes with a consideration of the different theories as to the existence and development of life, and with a study of the influences of heredity and environment.

If the value of the course in Biology as a training for the teacher of Natural Sciences be considered it will be found that the requirements for this profession are fully satisfied. The graduate of this course will have received more than a year of chemistry, both inorganic and organic, together with laboratory work in qualitative and quantitative anaylsis; a year of physics with laboratory work; mineralogy, geology, psychology, forestry and anthropology; and the biology, botany and zoology already described. His work in these subjects will have fitted him to teach them successfully in high schools, academies and in colleges, the ground covered having been much more than is generally taught in such places.

Another line of work is also available for graduates of this course. The Experiment Stations of this country are as yet but little understood and appreciated by the general public, but the work they are doing is one that must compel attention and appreciation. These stations are investigating every line where results of practical value to the farmer may be hoped for, and biological investigations form an important part of this work.

The study of conditions determining the health or sickness of stock; animal and vegetable parasites; the ravages of insects and how

they may be prevented; the relations of bacteria to the production of milk, butter and cheese, and to various crops; the biological examination of water, soil and air; microscopical examination of foods for the detection of adulterants; hygienic conditions of the home and its surroundings—these are all within the province of the biologist connected with the Experiment Station. At the present time the demand for competent men for these positions exceeds the supply, and remunerative positions in this line await the right persons to fill them.

Biologists are also now being employed in connection with Boards of Health investigating the problems of pure water supply, proper sewage systems, the determination and control of contagious diseases, and, as this line of development is recent, it is but reasonable to look for a demand for biologists to occupy positions of this kind in the near future.

In conclusion, Mr. President, I desire to express my appreciation of the recognition the biological work of the College has always received from the trustees and from yourself.

Respectfully submitted,

H. T. FERNALD,
Professor of Zoology.

State College, Pa., December 31, 1896.

III.--BOTANY AND HORTICULTURE.

A. BOTANY.

To the President:

Sir:—The instruction in the Department of Botany and Horticulture during the year 1896 has been as follows:

Winter Session.—Seniors (4), Plant Physiology, 2 hours per week; Juniors (4), Cryptogamic Botany, 4 hours per week, with practicum of 6 hours.

Spring Session.—Seniors (4), Forestry, 3 hours per week; Juniors (1), Phaenogamic Botany, practicum, 8 hours per week; Sophomores (8), Plant Study (introduction to Botany), practicum, 4 hours per week.

Fall Session.—Juniors (9), General Botany, 4 hours per week, with practicum of 6 hours; Juniors (5), Economic Botany, lectures, 2 hours per week.

I have also had a special class 4 times per week to accommodate a student who was permitted to take botany as an extra study. No work for the special courses in Agriculture was called for this year.

While the actual number of hours in the above schedule is somewhat less than some other instructors have, it calls for so much of practicum and illustration that close comparison of hours engaged becomes unmeaning. The necessity of practicum work in the study of nature is now undisputed. All our text books presuppose it, and are planned and written with direct reference to the laboratory method. The problem is how to co-ordinate it with text books and their study.

Happily the time has gone by when the mere memorizing of the facts of science will pass current. Such second-hand knowledge is better than none at all, but that is all that can be said in favor of it. The beneficial effects of the study of Biology and Chemistry which all our students now have, before my subjects are taken up, are plainly apparent in a better grade of work and in an evident better understanding of the work accomplished, and of its relation to that of other departments. I specify these two subjects simply because of their closer and more direct relation to my department. Good scholarship in any subject is beneficial to whatever follows it.

I have not found it necessary to condition any student during the year, although in a few cases the figures ran dangerously near the limit. It is evident that conditions during the latter half of a

college course of study will naturally be much less frequent than in the earlier half, and that the unpleasant duty of writing conditions largely devolves upon those teachers who give instruction in that earlier time.

Additions to apparatus and material for instruction have been but moderate, and a large part of the appropriation for that purpose is still unexpended. It has seemed well to move slowly in the matter until there is opportunity for a personal inspection and comparison of some things particularly desired. Meanwhile, current needs have been provided for as they arose, and it has been a great satisfaction to know that the department has its own fund to draw upon.

The laboratory fee of one dollar per session in Botany is, in the long run, quite inadequate, and I recommend that it be made two dollars, or abolished entirely. But little has been added to the herborium this year either by collection or purchase; but I am pleased to report and herewith to acknowledge the gift of 54 specimens from Dr. F. E. Tuttle, of State College.

The principal improvement to the buildings has been the introduction of electric light. It is hardly necessary to say that this is a very great convenience and adds materially to the use of them as I have frequently had occasion to prove.

The report from the Horticultural side of the department comes more naturally from my associate, Assistant Prof. Butz, who has the direct oversight of that work, although we sometimes find it necessary to interchange, and do not attempt to draw any hard and fast line of separation.

Aside from the preparation of one of the bulletins of the year my connection with the Experiment Station has called for more or less correspondence in replying to inquiries on botanical and other matters, and a small amount of service in the institute field.

Perhaps mention should likewise be made of my positions as executive officer during your enforced absence of several months early in the year.

With this brief enumeration of the principal events of 1896, I have only to add my profession of loyalty to the service of the institution and my warm appreciation of your cordial support.

Very truly yours,

W. A. BUCKHOUT,

Professor of Botany and Horticulture.

State College, Dec. 30, 1896.

B. HORTICULTURE.

To the President:

Sir:—I have the honor to present the following report of the Horticultural work of the year 1896.

There has been no change in the horticultural instruction as outlined in my previous reports and indicated in the College catalogue, owing to the fact that the three best months of the year for practicum work in Horticulture occur during the summer vacation. I have endeavored to acquire as much material as possible, which will serve in the winter days to familiarize students with the plants of cultivation. Along this line we have now dried specimens in herbarium style, about 700 pieces, illustrating as well as they may the summer condition of ornamental shrub, deciduous and evergreen trees, herbaceous and greenhouse plants, and also the winter condition of cultivated trees and shrubs. The Horticulturist has less respect than the Botanist for the native species of plants, but he regards the *varieties* which have been derived from these species as a sort of index of the progress in his art. The variations in plants, which have been brought about during their cultivation, are often of such a character that they can be well preserved in dried specimens, and thus an herbarium of varieties becomes as valuable to the student in Horticulture as is one of native species to the student in Botany.

Another feature of this work, which is practically only begun, is a museum of seeds. This began with a collection of weed seeds gathered upon the college farms and campus to serve in the identification of adulterations in garden and agricultural seeds. This was followed by seeds of the principal varieties of vegetables and, later, the design has been to include in an exhibit the seed of every species and variety of plants that might serve in botanical or horticultural study and that can be obtained. The seeds are stored in homeopathic vials with nickel screw tops, of three regular sizes with capacities, respectively, of 1 dram, 4 drams and 8 drams. Large seeds are put into one-half pint and pint museum jars. There are now about 1,500 samples in the collection.

A new feature in the conservatory is an acquarium which makes it possible for the first time to keep in a growing condition certain aquaries which have been much desired for botanical studies. We experience on all sides a great scarcity of space in the greenhouses, for carrying on all the work that could profitably be pursued in the in-

terest of our students. I wish to express my satisfaction in the work of the gardener, Mr. J. P. Pillsbury, and to commend him for his appreciation of systematic and scientific work which may be entrusted to him.

We are indebted to a number of friends of the college and to several prominent nurserymen and seedsmen for generous contributions of materials, valuable in a variety of ways to this department. I take this occasion to make acknowledgment of the principal donations of the year as follows:

From Wm. G. Waring, of Tyrone, Pa., formerly an officer of the college, several hardy shrubs were received.

From Geo. Baldwin, Oak Park, near Chicago, Ill., formerly gardener in this department, were received a box of plants on three different occasions, including 40 varieties of new chrysanthemums and 50 species of flowering plants and aquatics.

From Rev. Wm. Carey Calder, Rangoon, India, an alumnus of the college, of the class of '83, was received a fine collection of orchids, including about 100 plants or masses of pseudo-bulbs taken from their native haunts in the jungles of that warm country. There are represented in this collection about 40 species of orchids of both aerial and terrestrial kinds, most of them being exceedingly valuable in the market of this country. I have estimated that the cost of a similar lot of orchirds in the nurseries of America would be not less than $250.00. The plants were ten weeks in transit, and though they were in a very dry condition on arrival, with proper care every species was revived and several of them have already been producing their curious and magnificent flowers. It should be added that in the previous year a similar shipment was made to us by Mr. Calder, but, owing to a seemingly unnecessary detention of the package in our custom house, the plants did not reach us until six months after being packed up, and scarcely any life was left in them.

From J. M. Thorbum & Co., seedsmen, New York City, we received a collection of 175 species of seeds of cultivated trees and shrubs, both native and foreign. From Henry A. Dreer, seedsman, Philadelphia, we received 35 species of flowering plants, principally garden annuals.

From W. A. Burpee & Co., seedsmen, Philadelphia, we received 125 species of seeds including ornamental grasses, pot herbs and garden annuals.

From James Gurney, head gardener at the Shaw Botanic Gardens, St. Louis, Mo., we received 80 species of seeds, principally hardy perennials.

From Otto Bogula, St. Louis, Mo., we received 100 species of seed of cultivated plants.

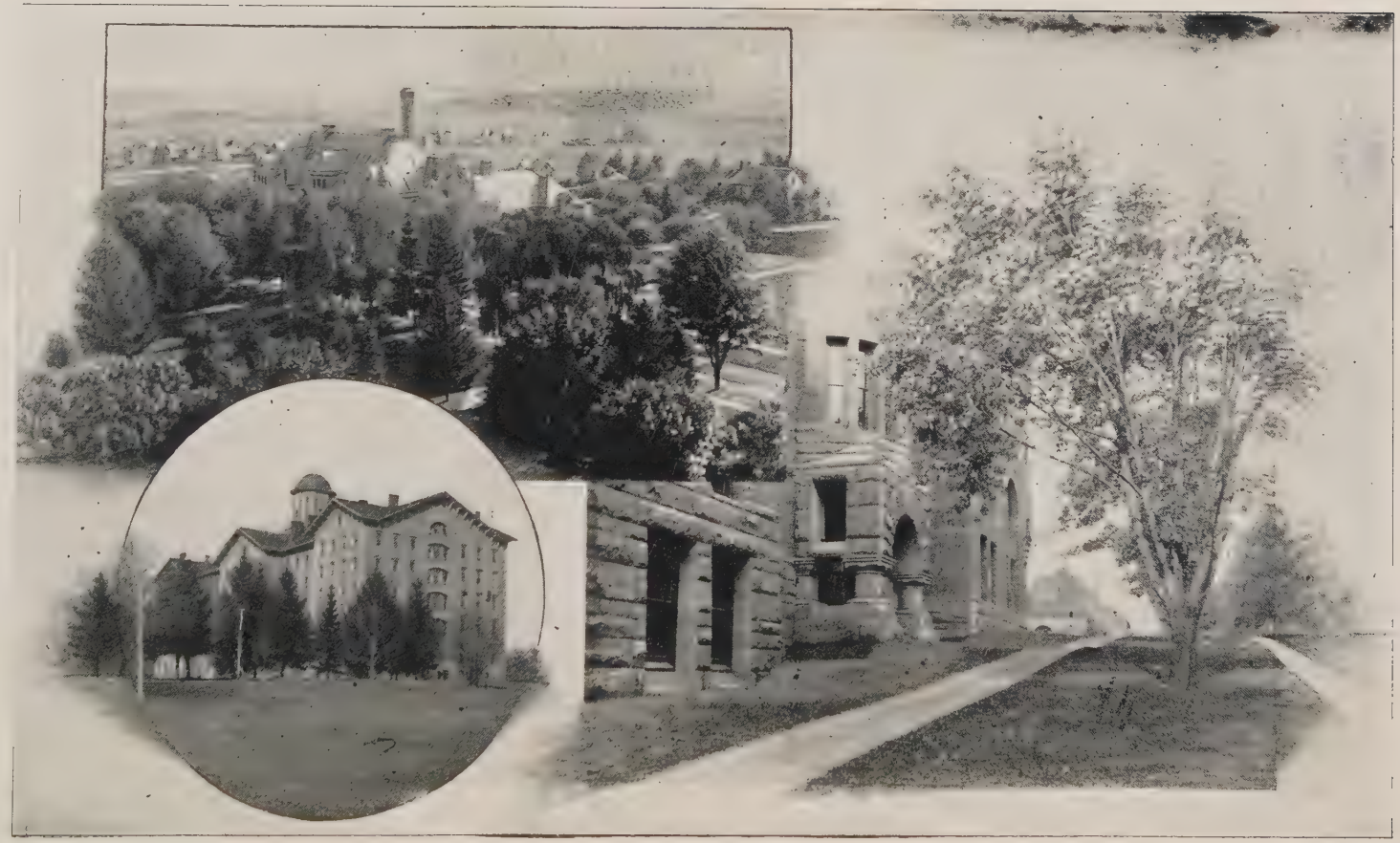
From J. P. Pillsbury, gardener at this institution, we received 275 herbarium specimens of cultivated trees, shrubs and plants, collected upon the grounds of the Missouri Botanic Gardens. A portion of these specimens represents the winter condition of deciduous trees and shrubs.

Many smaller contributions have from time to time been received and accredited in their proper places.

Respectfully submitted,

GEO. C. BUTZ,
Assistant Professor of Horticulture.

State College, Pa., Dec. 28, 1897.



Views on the College Campus.

IV.—CHEMISTRY.

To the President:

Sir:—The work of the Department of Chemistry for the last year has progressed along the usual lines with reasonably gratifying results.

Instruction in Chemistry is given to all College students during three terms, and twenty-eight students are enrolled in the various classes in the Course of Chemistry.

The innovation of two years ago, by which all students commence chemistry in the winter term of the Freshmen year instead of in the Sophomore year as formerly, has given entire satisfaction and can no longer be classed as an experiment. For the general and engineering students it is a vast improvement over the old regime because they now finish their year of general chemistry before the pressure of their special work becomes severe, and there is an opportunity for more advanced work in chemistry for such courses as require it. For our students who specialize in chemistry, the time gained by this arrangement will be particularly valued. The chemical students of the present senior class will be the last ones to graduate from the old course, the classes subsequent to '97 having commenced their chemistry earlier. We note with special gratification that the students to go out from the new course will be able, because of the additional two terms, to study a much wider range of topics than was the case with their predecessors, to their very decided advantage.

Qualitative Analysis.—After a thorough drill in the elementary principles of our science, our students are led into the field of Qualitative Analysis and in the last term devoted to this subject, the fall session of the Sophomore year, are able to determine with reasonable promptness any ordinary simple substance and many mixtures. Mixtures in solution are given involving all possible confusion of bases, and satisfactory separations and identifications are secured. Also substances in solid form, pure or impure, are given in great variety and the student is required not only to determine and report what the substance is but also to defend his method of analysis against criticism. As an illustration, the following substances have been issued in solid form and successfully solved during the term just closing. These substances, and, in some cases, mixture of two or more compounds, are introduced to show the character of the work

only and not to indicate that the course demands just these substances. The list is taken from my current memoranda and would be entirely different in detail any other year, though about the same in grade of difficulty and in variety. It is:

Acetate of Cobalt,
Acetate of Copper,
Acetate of Lead,
Acetate of Lead (Basic),
Acetate of Lithium,
Acetate of Manganese,
Acetate of Nickel,
Acetate of Strontium,
Acetate of Uranium,
Aluminate of Copper,
Aluminate of Sodium,
Ammoniacal Chloride of Iron,
Ammoniacal Nitrate of Copper,
Ammoniacal Sulphate of Copper,
Ammoniacal Nitrate of Nickel,
Antimonate of Potassium,
Antimonate of Sodium.
Arsenate of Copper,
Arsenate of Magnesium and Ammonium,
Arsenate of Potassium,
Arsenate of Sodium,
Arsenite of Copper,
Arsenite of Potassium,
Arsenite of Sodium,
Baking Powder (various),
Borax,
Boric Acid,
Brass,
Bromide of Aluminium,
Bromide of Cadmium,
Bromide of Lithium.
Bromide of Potassium with Iodide of Potassium,
Bromide of Strontium,
Bronze,
Carbide of Aluminium,
Carbide of Barium,
Carbide of Calcium,
Carbide of Strontium,
Carbonate of Barium with Sulphate of Barium,
Carbonate of Beryllium,
Carbonate of Lead (basic),

Carbonate of Lithium,
Carbonate of Manganese,
Carbonate of Uranium and Ammonium,
Chalcopyrite,
Chloride of Calcium,
Chloride of Chromium,
Chloride of Copper (cuprous),
Chloride of Gold and Sodium,
Chloride of Thallium (thalloso-thallic),
Chloride of Tin (stannic) and Ammonium,
Chlorate of Barium,
Chlorate of Strontium,
Chromate of Aluminium,
Chromate of Ammonium,
Chromate of Barium,
Chromate of Bismuth,
Chromate of Calcium,
Chromate of Cobalt,
Chromate of Copper,
Chromate of Copper and Ammonium,
Chromate of Iron,
Chromate of Lead,
Chromate of Lead (basic),
Chromate of Manganese,
Chromate of Magnesium,
Chromate of Nickel,
Chromate of Silver,
Chromate of Zinc,
Chrome Alum,
Chrome Iron Ore,
Chromic Acid,
Citrate of Bismuth,
Citrate of Bismuth and Ammonium,
Citrate of Iron,
Citrate of Iron and Ammonium,
Citrate of Magnesium,
Citrate of Nickel,
Citrate of Ammonium,
Citric Acid,
Coal (bituminous),
Copper Coin,
Dichromate of Calcium,
Dichromate of Copper,
Dichromate of Lithium,

Dichromate of Sodium,
Feldspar,
Ferric Alum,
Ferricyanide of Cadmium,
Ferricyanide of Potassium,
Ferrocyanide of Ammonium,
Ferrocyanide of Calcium,
Ferrocyanide of Copper,
Ferrocyanide of Iron,
Ferrocyanide of Potassium,
Ferrocyanide of Zinc,
Fluoride of Potassium,
Fluoride of Calcium,
Fluoride of Lead,
Formate of Barium,
Formate of Lead,
Formate of Strontium.
Galena,
German Silver,
Glass (various),
Hematite,
Hydroxide of Cadmium,
Hydroxide of Thallium,
Hypophosphite of Calcium,
Hyphophosphite of Sodium,
Hyposulphite of Sodium,
Iodide of Copper and Potassium,
Iodide of Lead,
Iodide of Magnesium,
Iodide of Mercury,
Iodide of Nickel,
Iodide of Silver,
Iodide of Strontium,
Iodide of Sulphur,
Iodide of Thallium (thallious),
Iodine,
Magnesite,
Magnetic Iron Ore,
Metallic Aluminium,
Metallic Cadmium,
Metalilc Cobalt,
Metallic Copper,
Metallic Copper (tinned),
Metallic Iron,
Metallic Iron (tinned),

Metallic Magnesium,
Metallic Nickel,
Metallic Platinum,
Metallic Silver,
Metallic Thallium,
Metallic Tin,
Metaphosphoric Acid,
Molybdate of Ammonium,
Molybdic Acid,
Nitrate of Bismuth (basic),
Nitrate of Lithium,
Nitrate of Silver,
Nitrate of Uranium,
Nitrite of Potassium,
Nitrite of Silver,
Nickel Coin,
Oxalate of Ammonium,
Oxalate of Cobalt,
Oxalate of Copper,
Oxalate of Iron (ferrous),
Oxalate of Lithium,
Oxalate of Manganese,
Oxalate of Magnesium,
Oxalate of Potassium (acid),
Oxalate of Potassium (neutral),
Oxalic Acid,
Oxide of Cadmium,
Oxide of Chromium,
Oxide of Copper with Peroxide of Manganese,
Oxide of Magnesium,
Oxide of Tin,
Oxide of Titanium,
Oxide of Uranium (black),
Oxide of Uranium (yellow),
Oxide of Zinc,
Oxychloride of Bismuth,
Oxychloride of Copper,
Paratungstate of Sodium,
Permanganate of Calcium,
Permanganate of Potassium,
Peroxide of Barium,
Peroxide of Manganese,
Peroxide of Sodium,
Phosphate of Aluminium,

Phosphate of Calcium,
Phosphate of Calcium with Oxide of Lead (cupels),
Phosphate of Cobalt,
Phosphate of Cobalt and Ammonium,
Phosphate of Copper,
Phosphate of Iron (ferric), (ortho-),
Phosphate of Iron (ferric), (pyro-),
Phosphate of Iron (ferrous),
Phosphate of Lithium,
Phosphate of Sodium and Ammonium,
Phosphate of Zinc (ortho-),
Phosphate of Zinc (pyro-),
Phosphite of Sodium,
Phosphomolybdate of Ammonium,
Phosphomalybdate of Sodium,
Phosphotungstate of Sodium,
Platinochloride of Ammonium,
Platinochloride of Potassium,
Potassium Amalgam,
Pyrite,
Rutile,
Selenium,
Silica,
Silicate of Calcium,
Silicate of Potassium,
Silver Coin,
Smalt,
Soda Lime,
Sodium Amalgam,
Sulphate of Bismuth,
Sulphate of Calcium (cryst.),
Sulphate of Cobalt and Potassium,
Sulphate of Iron with Sulphate of Magnesium,
Sulphate of Iron and Ammonium with Sulphate of Nickel and Ammonium,
Sulphate of Magnesium and Ammonium,
Sulphate of Mercury (basic),
Sulphate of Tin and Potassium,
Sulphide of Antimony,
Sulphide of Arsenic,
Sulphide of Barium,
Sulphide of Cadmium,
Sulphide of Calcium,
Sulphide of Copper,
Sulphide of Mercury,

Sulphide of Potassium,
Sulphide of Silver,
Sulphide of Tin (stannic),
Sulphite of Potassium,
Sulphite of Sodium,
Sulphocyanide of Ammonium,
Sulphocyanide of Iron,
Sulphocyanide of Potassium,
Sulphur,
Tartaric Acid,
Tartrate of Aluminium,
Tartrate of Antimony and Potassium,
Tartrate of Bismuth,
Tartrate of Iron and Ammonium,
Tartrate of Lithium,
Tartrate of Manganese,
Tartrate of Potassium (acid),
Tartrate of Potassium (neutral),
Tartrate of Zinc,
Tellurium,
Thallium Alum,
Tin Amalgam,
Tin Foil (lead alloy),
Tungstate of Sodium,
Type metal,
Ultramarine Blue,
Ultramarine Green,
Ultramarine Red,
Ultramarine Violet.

Minerals are for the most part avoided, being introduced only by a few types, because our curriculum includes a term of work devoted exclusively to Determinative Mineralogy.

Quantitative Analysis—With the beginning of their fourth term in Chemistry, students commence to receive instruction in Quantitative Analysis. In this subject we have to provide for several different kinds of students, having diversified needs, as follows:

Students in the Course in Chemistry,
Students in the Course in Mining Engineering and Metallurgy,
Students in the Course in Biology,
Students in the Course in Agriculture,
Students in the Course in Electrical Engineering.

It is our aim to keep our beginners in Quantitative Analysis together as far as practicable at first, but to admit of such differentiation as is necessary as soon as the interests of the students demand it. In practice, we find them separating from each other

very soon after the start. We believe most thoroughly that the best results are obtained by assigning first the determination of single bases and acids in substances as nearly nearly pure as possible in which the percentage of the constituent sought is precisely known, making the study of ores, alloys and all products of variable composition a later exercise. Hence the large use of crystalized double salts and other similar bodies of well known and invariable composition. To seek a specific illustration, we think that the student should first familiarize himself with the determination of zinc in zinc ammonium sulphate, or some similar but pure compound, before he is given the determination of the same metal and its separation from other bodies in an ore, alloy or other zinc containing substance of unknown or variable composition. In other words, quantitative determination first, quantitative separation afterwards, is our general rule. All determinations are required in duplicate, and, after exercises of this character have been given to such an extent that the student shall have made determinations of all, or as many as possible, of the various bases and acids, singly, he may then be promoted to the quantitative separation of constituents and to the complete analysis of ores, minerals, alloys and commercial products. These views can of course be best carried out with our chemical students as they have most time for the subject and are expected to master it most thoroughly. Students of Mining and Metallurgy come next in order of time devoted to this work, but even with them, we have to subordinate to some extent the thorough study of Quantitative Analysis as a subject, to the requirement that these students must accomplish certain important analyses within the alloted time. With those students in Agriculture, Electrical Engineering, etc., who remain in the Quantitative Laboratory for a single term only, and with whom it is a matter of difficulty to secure even a single additional hour per week for Chemistry when wanted, because of the pressure of their special subjects, it is always necessary to so modify the course as to secure the maximum of essential work with a minimum of time.

The determination and analyses performed by the different divisions of students are here enumerated in some detail. It is not to be assumed that the following lists show an inflexible course; on the contrary, there may be marked variations from year to year, and we do not aim at a stereotyped requirement. From time to time we can make improvements in the list and are always ready to do so, but the list shows the character of the work as performed this year. The full lists indicate the full course, such work as we would like to accomplish with all and do accomplish with the more progressive students. Asterisks indicate possible omission for minimum of requirement.

For Students in Course in Chemistry.

Determination of—

Chlorine, in pure salt, as silver chloride,
Copper, in pure blue vitriol, as oxide,
Copper, in pure blue vitriol, as sulphide,
Copper, in pure blue vitriol, as metal by electrolysis,
Sulphuric acid, in pure blue vitriol, as barium sulphate,
Water, in pure blue vitriol, direct and indirect,
Nickel, in nickel ammonium sulphate, as oxide,
Nickel, in nickel ammonium sulphate, as metal by reduction with hydrogen,
Nickel, in nickel ammonium sulphate, as metal by electrolysis,
Iron, in ferrous ammonium sulphate, as oxide,
Magnesium, in magnesium ammonium sulphate, as pyrophosphate,
Manganese, in manganese ammonium sulphate, as pyrophosphate,
Zinc, in zinc potassium sulphate, as oxide,
Zinc, in zinc potassium sulphate, as sulphide,
Zinc, in zinc potassium sulphate, as pyrosphosphate,
Aluminium, in pure alum, as oxide,
Calcium, in pure calcium carbonate, as oxide,
Barium, in pure barium chloride, as sulphate,
Barium, in pure barium chloride, as carbonate,
Phosphoric acid, in microcosmic salt, as magnesic pyrosphosphate,
Chromium, in potassium chromate, as oxide,
Arsenic, in arsenious oxide, as sulphide,
Arsenic, in arsenious oxide, as magnesic pyroarsenate,
Antimony, in tartar emetic, as sulphide,
Antimony, in tartar emetic, as tetroxide,
Lead, in plumbic nitrate, as sulphate,
Potassium, in potassium chloride, as platinochloride,
Ammonium, in ammonium chloride, as platinochloride,
Titanium, in ilmenite, as oxide.

Volumetric determination of—

Iron, by permanganate method,
Iron, by dichromate method, with ferricyanide as indicator,
Calcium, by permanganate method,
Manganese, by permanganate method,
Chlorine, by silver nitrate method, with chromate as indicator,
Potassium and sodium, indirect determination,
Silver, by sulphocyonide method (Volhard),
Copper, by sulphocyanide method (Volhard),
Chlorine, by sulphocyanide method (Volhard),
Bromine, by sulphocyanide method (Valhard),
Iodine, by sulphocyanide method (Volhard),
Nitric acid, by method of Pelouze,
Nitric acid, by method of U. C. Schulze modified by Tiemann,
Acidimetry and alkalimetry,
Ammonia, by distillation, absorption, and subsequent titration.

Complete analysis of—

Brass,
Bronze,
Type metal,
Marble,
Limestone,
Dolomite,*
Zinc blende,
Chalcopyrite,
Galena,*
Natrolite,
Pectolite,*
Calamine,*
Feldspar,
Clay,
Iron ores, iron, silica, titanium, manganese, sulphur, phosphorus and water),
Iron and Steel (silicon, titanium, manganese, sulphur, phosphorus and carbon,
Slag,
Coal (sulphur ash, volatile and fixed combustible matter, and silica),
Coke (sulphur, ash, silica and phosphorus),
Water (potable, and for manufacturing purposes),
Fertilizers,*

Soap.*
Vinegar.*
Urine (urea, phosphoric acid, chlorine, sulphuric acid, uric acid, albumen and sugar).
Oils.*
Baking powders.*

Valuation of—

Pyrolusite,*
Chromite,*
Tannery liquors.*

For Students in Courses in Mining and Metallurgy.

Determination of—

Chlorine, in common salt, as silver chloride,
Copper, in blue vitriol, as oxide.
Copper, in blue vitriol, as sulphide.
Copper, in blue vitriol, as metal by electrolysis,
Sulphuric acid, in blue vitriol, as baric sulphate,
Water, in blue vitriol, by indirect method.
Nickel, in double sulphate, as oxide.
Nickel, in double sulphate, as metal by electrolysis.
Iron, in double sulphate, as sesquioxide.
Magnesium, in double sulphate, as pyrosphosphate.
Calcium, in calcite, as oxide.
Manganese, in double sulphate, as pyrosphosphate,
Phosphoric acid, in microcosmic salt, as magnesic pyrosphate.
Barium, in baric chloride, as sulphate.
Aluminium, in double sulphate, as oxide.
Zinc, in double sulphate, as oxide.
Zinc, in double sulphate, as pyrosphosphate.
Arsenic, in arsenious oxide, as tri-sulphide.
Arsenic, in arsenious oxide, as magnesic pyroarsenate.
Lead, in lead nitrate, as sulphate.

Volumetric determination of—

Iron, by permanganate method,
Iron, by dichromate method, with ferricyanide as indicator,
Chlorine, by silver method, with chromate as indicator.
Calcium, by permanganate method,
Manganese, by permanganate method,
(Copper, by sulphocyanide method, acc. to Volhard.)
(Silver, by sulphocyanide method, acc. to Volhard.)
(Chlorine, by sulphocyanide method, acc. to Volhard.)
(Bromine, by sulphocyanide method, acc. to Volhard.)
(Acidimetry and alkalimetry.)

Complete analysis of—

Brass,
Limestone,
(Zinc blende),
(Chalcopyrite),
Galena,
(Natrolite),
Clay,
Iron ores (iron, silica, titanium, manganese, sulphur, phosphorus and water),
Iron and steel (sulphur, phosphorous, manganese, silicon and carbon),
Slag,
(Water),
Coal (volatile and fixed combustible matter, sulphur, ash and silica),
Coke (ash, sulphur and silica).

Note.—The analyses enclosed in parenthses are omitted by mining engineers, but all are taken by metallurgists.

For Students in Agriculture and in Electrical Engineering

Determination of—

Chlorine, in common salt, as silver chloride,
Copper, in blue vitriol, as oxide,
Copper, in blue vitriol, as sulphide,
Copper, in blue vitriol, as metal by electrolysis,
Sulphuric acid, in blue vitriol, as barium sulphate,
Water, in blue vitriol, by indirect method,

Nickel, in double sulphate, as oxide,
Nickel, in double sulphate, as metal by electrolysis,
Iron, in double sulphate, as oxide,
Magnesium, in double sulphate, as pyrosphosphate,
Manganese, in double sulphate, as pyrosphosphate,
Zinc, in double sulphate, as oxide,
Zinc, in double sulphate, as pyrosphosphate,
Calcium, in calcite, as oxide,
Chromium, in potassium dichromate, as sesquioxide,
Aluminium, in alum, as oxide,
Potassium, in potassium chloride, as plantinochloride,
Ammonium, in ammonium chloride, as platinochloride,
Iron, volumetrically, by permanganate method.

For Students in Biology (Proposed).

Determination of—

Chlorine, in salt, as silver chloride,
Copper, in blue vitriol, as oxide,
Copper, in blue vitriol, as sulphide,
Copper, in blue vitriol, as metal by electrolysis,
Sulphuric acid, in blue vitriol, as baric sulphate,
Nickel, in double sulphate, as oxide,
Nickel, in double sulphate, as metal by electrolysis,
Iron, in double sulphate, as sesquioxide,
Magnesium, in double sulphate, as pyrosphosphate,
Manganese, in double sulphate, as pyrosphosphate,
Zinc, in double sulphate, as oxide,
Zinc, in double sulphate, as pyrophosphate,
Calcium, in calcium carbonate, as oxide,
Phosphoric acid, in microcosmic salt, as magnesium phosphate,
Chromium, in potassium dichromate, as sesquioxide,
Aluminium, in double sulphate, as oxide,
Arsenic, in arsenious oxide, as sulphide,
Arsenic, in arsenious oxide, as magnesium pyroarsenate,
Potassium, in potassium chloride, as plantinochloride,
Ammonium, in ammonium chloride, as platinochloride,
Lead, in lead nitrate, as sulphate.

Volumetric determination of—

Iron, by permanganate method,
Iron, by dichromate method, with ferricyanide as indicator,
Chlorine, by silver method, with chromate as indicator,
Acidimetry and Alkalimetry,
Water for domestic purposes,
Urine.

Assaying. — This subject, though strictly a branch of Quantitative Analysis, stands so much by itself as regards methods commonly employed that its work is usually accomplished as a separate topic in a special laboratory. Our facilities for instruction in this branch, both as regards material and instructors, are adequate and satisfactory for present needs but they are not flexible or capable of much expansion. Larger facilities will soon be needed to meet the demands of a constantly increasing number of students who call for instruction in this branch.

The course in Assaying, as reported to me by the Instructor in Assaying, consists as at present scheduled of four hours per week during the fall session. Although originally planned to use this time in two sections of two hours each, it has been found advisable to throw them together into one four hour exercise, as the character of the work is such that far more satisfactory work can be done in one long period than in two short ones. Senior Chemists and

Mining students, together with the short course mining men, are required to take this course.

The course commences with the scorification assay of silver. After assaying about twelve different silver ores of varying degrees of richness, ores which contain gold are issued, the students determining both the gold and silver in them.

The crucible assay for gold and silver is next introduced and practiced with several ores.

The lead assay is then taken up, and carried on until the student is familiar with it and good results are secured on several different ores.

Incidentally the assay of fuel is taken up, the principal determinations in coal being carbon, coke and ash.

The dry assay of tin, nickel and cobalt is learned by such students as care to spend sufficient extra time on this study.

The wet assays of copper, zinc, silver, nickel and iron are relegated to the regular quantitative analysis practicum.

The stress of the work in Assaying is placed on silver, gold and lead assays. All possible varieties of ores which are ever met with in practical work, are given to the students for analysis. The different products of smelting works, samples taken at different stages of the copper and lead processes, as well as alloys and bullion, all receive some attention.

The time devoted to Assaying in our curriculum should be at least doubled in all the courses where it occurs, as the Instructor feels that he has less than half as much time allotted to his work in this branch as is fairly needed.

Gas Analysis—In this branch we are now equipped to accomplish almost any class of work for which we are likely to be called upon.

To seniors in Mining and Mechanical Engineering courses, I have several times given an abbreviated course of instruction covering such detail as is necessary for the determination of the three constituents most commonly determined in flue gases and producer and furnace gas, namely, carbon monoxide, carbon dioxide and oxygen. The apparatus of Orsat-Lunge receives special emphasis for this technical work. The Shaw apparatus for ignitible gas in mine air is also explained. More was not possible with the very limited time at our disposal. This work should be made a regular and required part of the curriculum and the time extended at least enough to take in the determination of hydrogen and methane. Especially is this desirable for the students in the course in Mining.

The gas analysis work for chemical students is more extended and includes complete analysis of chimney, producer and furnace gases; of air, including the careful determination of carbon dioxide in min-

ute quantities, and of illuminating gas. Apparatus of Bunte, Winkler, Orsat-Lunge, Elliott, are used in succession, but that of Hempel is preferred and, when this is reached, all others are set aside for the rest of the week.

The constituents determined are:

Carbon monoxide,
Carbon dioxide,
Oxygen,
Unsaturated hydrocarbons,
Acetylene,
Benzene,
Other heavy hydrocarbons,
Methane,
Hydrogen,
Nitrogen.

All known absorption methods are employed; for oxygen the nitric oxide method is introduced; for single known ignitible gases the Shaw apparatus is used; for carbon dioxide Pettenkofer's, Pettersson's and Wanklyn's methods are introduced; for marsh gas and hydrogen, the paladium method, the explosion methods, the glowing platinum method, and the combustion tube methods are taught.

When each student can perform a creditable analysis of air, and of any illuminating gas which may be offered, we feel that sufficient progress has been reached for present purposes.

It is my intention to report with this degree of detail, at this time, only the analytic and inorganic portion of the instruction offered in the Department of Chemistry, and even from this some advanced topics have been omitted. On these omissions as well as on the work in organic, synthetic, medical and sanitary chemistry, I shall be pleased to make report at a later date, or at any time when desired.

Material Equipment.—Since my last report, the additions to the laboratory equipment, made from time to time, have consisted in the main of standard perishable apparatus and chemicals, of which classes of goods our annual consumption is now very considerable. Yet some other material has been added, notably four Becker, Rotterdam, aluminium beam balances; some eight hundred labelled reagent bottles; also large additions to our museum.

Laboratory Limitations.—I called attention last year to the cramped space in which our quantitative work has to be performed. The pressure is greater this year and conditions will very soon call loudly for a supplementary quantitative laboratory. The schedule committee are now struggling with my demand for a daily schedule for the winter term which will successfully place forty men in a laboratory designed for fifteen or eighteen.

The original plan of the laboratory made no provision for or-

ganic work. A small room, designated on the original plans as "Laboratory for Special Students," has done duty as an organic laboratory thus far. This room, too, has become entirely outgrown and we are now in need of a larger laboratory room to be devoted to that important branch of our science which articulates most closely with Botany, with Physiology, and with all the functions of life whether plant or animal;—that branch which is so essential to the education not only of the chemist but of the general student as well;—the branch to which we owe our knowledge of anaesthetics and drugs, of most medicines, foods and poisons, of the important industries of the petroleums, the starches and sugars, paper and leather, of all fibres, of alcohol;—the branch without which we could have no science of Medicine and no science of Agriculture: and yet a branch which is too often shamefully neglected in College curricula.

Our gas analysis work is also crowded out of the laboratories and has to be performed at present in the lecture rooms. The same is true of parts of the work in water analysis. The arrangement by which a lecture table is occupied one period by students performing experimental work, and the next by an Instructor with a class, is a most clumsy, inconvenient and irrational one, but this annoyance is forced upon us.

I have now pointed out that more laboratory space is wanted for Quantitative Analysis, for Organic work, and for Gas Analysis, and I would respectfully inquire whether the time may not perhaps be at hand when we may reasonably ask that the attic room be fitted up so as to afford relief laboratories in the directions mentioned.

Museum of Chemical Industry.—With the results of solicitation during the year for contributions to our museum, I have reason to be measureably satisfied. One hundred and fifty firms in Germany promised samples of their products: forty English manufacturers did the same. More than half of these donations have been received; others are due at any time. As the gifts have been acknowledged individually to the donors, it is not necessary to enumerate them here. Unfortunately the museum material can not be fully displayed at present as we have filled all our cases to overflowing and can not at once build others. I hope for the continuous support and rapid growth of this feature.

Summer School.—I wish to take this opportunity of stating that this Department may be counted on as ready to co-operate in the plan which contemplates a Summer School for teachers at the College. It would seem probable that a course in general chemistry with experimental lectures and laboratory work, also a course in qualitative analysis would be helpful to such citizens of the State as might at-

tend the proposed Summer School. We can arrange for such courses without difficulty. More advanced courses may also be offered as occasion may demand, and, in every respect, I wish to assure you of our cordial support of the proposed Summer School.

Graduate Students.- One graduate from the course in Chemistry has earned the Doctor degree at a German university during the year; one has been entered as a candidate for the same at Goettingen and is engaged in the work there. One was granted the Master's degree at this College at our last Commencement, having submitted an acceptable thesis as the result of a very creditable piece of advanced chemical work, performed under our eye here, while three others are now candidates for the same academic rank, one of them resident, the other two non-resident.

Instruction Force — In accordance with plans previously laid down, Assistant Professor Tuttle has had almost independent care of the Quantitative work and is relieved of most other duties. This work is arduous and most important and, I can assure you, it is being thoroughly well performed. While Dr. Tuttle can give some time to certain other duties during the fall and spring sessions, his entire time goes to this work in the winter, and he should have assistance during that session.

Dr. F. J. Pond, a graduate of this College, who occupied a position as assistant in the laboratories in 1893 and 1894, having spent two years in studying in Europe, first at the University of Goettingen, where he received in February last the degrees of Master of Arts and Doctor of Philosophy, with predicate, *magna cum laude*, later in Freiberg in Saxony, at the Royal Mining Academy, was appointed, about January first, to be Instructor in Assaying, his duties to commence September first, 1896. This position is the one established with especial reference to the needs of the Engineering and Mining students. The incumbent has direct charge of the Assaying Laboratory, and so shares the other work of the force that we can take care of those Engineering students who are scheduled for Quantitative Analysis, and that we also can so divide the first year students as to maintain the maximum and minimum courses in Qualitative Analysis in such manner that the Engineers, though allotted a more limited time for this work, may be enabled to round out a course which may be reasonably complete, though unfortunately abbreviated. The Instructor in Assaying brings to his position a freshness from the chemical atmosphere of the German University Laboratories which all who experience it find most helpful, an enthusiasm and vigor in his work and a devotion to duty which will, I trust, be maintained so as to count much for the strength of our Department.

Dr. W. J. Keith, appointed as an Instructor in the Department at

the opening of the last winter term to replace Mr. C. A. Browne, Jr., who had to leave on account of illness at that time, is also a graduate of a German University, a thorough scholar and a most desirable addition to our force. He brought to us also the results of an extended experience in teaching in other American institutions. His assistance in the museum and in general laboratory matters has been invaluable and he has also relieved us of the instruction in Organic and Theoretical Chemistry, branches which he is eminently fitted by experience and training successfully to handle, and which, at his hands, are receiving more thorough treatment than could be given them before.

Mr. Browne continued to serve us faithfully and satisfactorily as general assistant from the date of my last report until about February first, when, being obliged to leave because of illness, his place was taken, as above stated, by Dr. Keith. Mr. Browne was later employed by the Experiment Station where he now is.

Mr. W. P. Smiley, who had been engaged January first to serve during the rest of the College year, was re-engaged at Commencement to be general assistant during the present year. He is entitled to our warm endorsement for faithful and efficient service.

It remains to be mentioned that Mr. J. C. Attix, a graduate of Lafayette, was called to assist us from January first through the rest of the College year, to relieve the severity of our work during those two terms; that he acquitted himself with dignity and successfully carried the work he was called upon to do during the period for which he was engaged.

Here I would state that the pressure of our work in the last half of the College year has rendered it necessary for me to ask in recent years for the additional assistance of one person during the winter and spring terms. This was the case two years ago when Mr. Browne was secured, and again one year ago, when Mr. Attix was engaged. The conditions are essentially the same now, and I have thought it almost necessary to ask the same consideration now as was liberally accorded me on the two previous occasions; but, on reviewing the situation, I have resolved to carry the work for this year without the additional helper. The burden will be a little greater upon each of us, and though I consider that we are all sufficiently loaded with work now for the best accomplishment, we will nevertheless make the attempt this year to get along without increase of help after January first.

With the renewal of all former expressions of thanks and appreciation of the cordial support always afforded me, I respectfully submit this report.

G. G. POND,
Professor of Chemistry.

State College, Pa., December 15th, 1896.

ENGINEERING BUILDING—WEST SIDE

V.—ELECTRICAL ENGINEERING.

To the President:

Sir:—I have the honor of presenting to you a report on the Department of Electrical Engineering for the year 1896. The general policy inaugurated when the Department was established in the spring of 1893 has been continued, though the work has been greatly developed and systematized since that time. As I have stated in previous reports, our general policy in regard to our students has been to train them thoroughly in the conception and application of the physical laws underlying the practice of electrical engineering. The mere acquirement of facts and details is unquestionably secondary to this, and our endeavor is to make the student feel that he is taking the course, primarily, to cultivate and enlarge his mental powers; secondly, thoroughly to understand those laws of nature and society which will best fit him to perform his duties in the sphere of life he has chosen; and thirdly, to gather information based upon these laws, which is of especial service to the engineer. This last and least important function of the college training is in a large number of cases considered by students, during the early part of their course, to be the essential feature. Many students feel that the study of English or of foreign languages, political or social science, much of the advanced mathematics, mechanics, or chemistry, and many other branches, is a waste of their time. Even when pursuing the technical subjects, it is not uncommon for a student to inquire why he is required to go through a vigorous course of reasoning to obtain a result, when the meaning and use of the result itself seem perfectly evident without such a demonstration. An engineering school might easily and quickly teach a man to design a dynamo, a transformer, or a steam engine by rule of thumb, to throw the proper switches, or to open the correct valve to operate such apparatus, or explain to him the details for wiring a house or for placing a water wheel; but though he be crammed with useful information of this kind, he would certainly not be an engineer. He might be a mechanic, but he would lack the mental training and knowledge of fundamental natural law that are essential to the execution of engineering work. A case developed by two of our seniors while engaged upon thesis work might be appropriately cited in illustration of the ease with which a man trained in the details

only of the task at hand, without understanding the principle involved, may make a serious mistake. The students were testing a street railway plant in a neighboring town. The power plant consisted of two steam engines and two generators coupled in parallel. The plant seemed much over-loaded, and by the advice of the superintending engineer, the company was negotiating the purchase of a new generator. The engineer in charge was a practical man, having the kind of training spoken of above. The students discovered that one generator was not only driving all the cars on the line, but was also driving the other generator as a motor, which, in turn, was driving its steam engine and countershafting. Since the advent of electricity as an agent for giving us light and conveyance, reference could be made to a number of examples where light or railway companies have failed, simply because the engineer in charge did not have the thorough and liberal training required successfully to meet difficulties or changed conditions as they arose.

Such a misconception of the true aim of a technical education as is suggested above has brought many applications for special courses composed mainly of descriptive matter, but you have had the full co-operation of the Department in universally advising against such courses, except in cases of financial necessity, and, under no circumstances, have students received certificates in electrical engineering unless their course was of at least three years duration. There have been two three year certificates issued thus far, and, to secure them, the regular engineering training of the first two years was required, with a third year composed largely of technical work in steam and electricity.

Class Room Study.

This year shows an important step in advance in the arrangement of our schedule of electrical work. The course now begins in the last term of the sophomore year and extends without break until graduation. Heretofore the work has begun with the junior year. The major course now consists in the study of electricity and magnetism during the Sophomore Spring Session and one-half of the Junior Fall Session, continuous current dynamos during the remainder of the Junior year, and alternating current machinery throughout the entire Senior year. This work, in a general sense, consists in the pursuance of one continuous course for two years and one term and forms the fundamental frame work about which are grouped the more special branches of applied electricity, such as electric lighting, telegraphy, electric railway work, telephony, electro-metallurgy, electro-chemistry, etc.

The preliminary study in electricity and magnetism is essentially a preparatory training for the more strictly technical work of the Junior and Senior years in dynamos and alternators. In this part

of the course the student is expected to become conversant with the fundamental laws of magnetism and electricity, and to apply them to simple cases with the familiarity and ease with which he applies the rules of arithmetic or algebra. With the course on electrical machinery begins a careful training in the application of those principles to engineering work and in their development and extension. The instructors endeavor to teach the work much in the same manner as is done in the teaching of geometry. The student is expected to reason out logically each point presented and is not permitted, under any circumstances, to go through the formal process without making it evident that he fully appreciates and understands each step. The methods of teaching employed in this course are possibly, in certain features, more clearly expressed in a portion of the preface of one of the text books in use, from which I take the liberty of selecting as follows:

"A treatise on electro-magnetism or on alternating currents should deal with its subject in much the same way that thermo-dynamics and the steam engine, hydraulics and hydraulic machinery, or the theory of structures are respectively presented in the best works on these subjects. The startlingly rapid advance which has been made in our knowledge of the phenomena relating to the electro-magnetism and the electric current, tends to confuse the best teachers, and doubtless accounts for the rather superficial methods used in many colleges, in which results only have been presented to the students, with little reference to reasons. This error is generally admitted. Descriptions and illustrations of special types of commercial machinery and of classical experiments should not be given merely for their own value, but when they may be made useful in illustrating the deductions of the work of the class. The mathematics used are merely a means to an end, and should by no means be considered from any other standpoint. In this respect it is sought to avoid either the error of presenting unnecessary formula, or, on the other hand, of giving results without reasons, both of which are fatal to the reader's true progress, as they leave him with no true physical conception of the phenomena studied."

An outline of the complete dynamo, or electrical machinery course, as it is taught, is somewhat as follows:

The electro-magnetic circuit.

The practical measurement of magnetic quantities.

Materials of construction.

The development of electrical pressure and the continuous current armature.

The continuous current dynamo field.

Armature reactions, commutators, sparking, etc.

Dynamo characteristics, including their determination.
Efficiencies and dynamo testing.
Coupling and regulating dynamos.
Multipolar dynamos.
Dynamo design.
Electric pressure of alternators.
Alternator armatures.
Self-induction and capacity, with methods of measuring.
Graphical and analytical solutions of alternating circuits.
The magnetic circuit of alternators.
Alternator characteristics.
Alternator regulation and combined output.
Alternator efficiencies and methods of testing.
Alternator design.
Mutual induction.
Operation of ideal transformer and effect of losses.
Efficiency and losses of transformer with methods of measuring.
Design of transformers.
Polyphase conducting systems.
Measurement of power in polyphase circuits.
Synchronous alternating current motors.
The rotary field.
The induction motor, single phase and polyphase.
Testing alternating current motors.
Alternating current motor designs.
Resolution of alternating current curves.
Oscillating discharges.
Electrical resonance.

In giving the following brief description of the more specially technical branches that are carried along with the central line of study which has just been described, I quote largely from my report to you for the year 1894.

The class work given in electro-metallurgy is essentially a discussion of the different methods of electrically refining metals, of electro-plating, and of electro-typing. During the time the lectures are being given practice in the work is carried on in the laboratory.

Lectures are given on the higher class of instruments used in an electrical laboratory and the proper modes of manipulating them. The instructor takes the instruments apart in the lecture room, thus illustrating the internal workings and construction, and divesting them of the sense of mystery which frequently attaches itself to the mind of the student in connection with some of the enclosed, high-priced instruments.

In the Spring session of the Junior year Primary and Secondary Batteries are treated. Lectures are given on the theory, methods of

operation and construction of the principal forms of primary cells, also on the standards of electromotive force, the proper cells to use in testing and for application to the industrial arts. The secondary battery is assuming such an important place in its relations to lighting, railways, signals and other large electrical industries that it must receive careful attention in every electrical course. Not only are the theories, chemical reactions and electrical phenomena carefully set forth, but a consideration of the principal commercial batteries is had with the conditions under which they may be successfully operated and the management they must have if good service is to be obtained. The results that have been secured in this country and abroad are analyzed, thus showing the weak points that must be avoided and the lines on which probable improvement can be made.

Electric Lighting is taken up by a careful study of the different systems of distribution used in arc and incandescent lighting, and the advantages and disadvantages of each are discussed from both financial and engineering standpoints. After this the machines in use in the different systems are treated and a study is made of the methods and apparatus used in their regulation. Considerable time is spent on the proper arrangement and wiring of switchboards, on the switchboard instruments in most common use for regulating, measuring and testing, and on the best methods of protecting machines and circuits from lightning. The student is made familiar with the manufacture of cables for underground work, and with the materials used in overhead and conduit systems of distribution.

A few lectures are given on the manufacture of the incandescent lamp, and the mechanism of the principal forms of arc lamps. A discussion of the relative merits of the meter and contract systems of selling power brings with it a study of the various meters in the market. A proper arrangement of boilers, engines and dynamos in a central station is obtained by the study of typical plants in operation throughout the country and abroad; and the use of the storage battery in connection with lighting stations is made the subject of careful consideration.

The College lighting plant gives an opportunity for instruction in the running of machines; and commercial tests are made of the plant and of the distributing system.

Problems involving the calculation of wire and material needed for the various systems of distribution are solved and specifications for the interior wiring of some of the college buildings are made. In this way it is hoped that incidentally the student will gain a knowledge of the rules of the Underwriters' Association.

The reading of engineering periodicals is stimulated by frequent references during lectures and recitation to published articles bearing upon the subject matter, and the student is required to prepare

a paper upon some point of interest in connection with the work. The subjects for these papers are assigned by the instructor in charge, and economic questions as well as purely engineering ones are given due attention.

In the Fall term of the Senior year the special applications of electricity to the Telephone and Telegraph are taught with the details and construction of the apparatus, particular attention being paid to the wiring of the latest forms of metallic circuit multiple telephone boards. The construction of cables for use in these industries is illustrated and explained and the testing of instruments and circuits by various accepted methods is practiced. The tests are made in the laboratory and on local lines. Both overhead and conduit line construction are carefully taken up and special attention is paid to the requirements of public contracts.

A synopsis of the treatment of Electric Railways and Transmission of Energy is somewhat as follows: the engines and boilers, their power, capacity, arrangement and method of installation; the generators, their type, method of control and disposition in the dynamo room; the proper arrangement of the switchboard and the instruments to be used; the line work, including the various trolley and conduit constructions; the track, the method of laying with the weight and bonding of the rails; the motor equipments and car wiring; the type, power and control of the motor and the requirements for special conditions; storage battery traction; statistics showing the earning capacity of railroads through a wide range of conditions; the plant management; statistics from which the various items of expense in operating an electric road may be deduced; high speed electric traction; and also the best mode of transmitting and applying power to mills, mines, towns, etc., from distant points where energy may be developed at a lower cost. The last point is deserving of full treatment as the transmission of power through long distances is coming to be an important feature in electrical engineering, and also the application of electricity in shops to cranes, large machines, shifters, etc., is rapidly gaining favor, due to its ready adaptation to different conditions and its economy.

Electricity in Mines is treated in lectures on the application of electricity for power and lighting purposes in mines, and a special course in Metallurgy involves a consideration of the leading practical methods for the electrical separation of metals.

One of the most important acquirements of the engineer is the ability to draw up Estimates, Proposals and Contracts properly, and a knowledge of the laws pertaining thereto and to charters, rights of way, etc. Inadequate specifications have perhaps done more to hinder the progress of the electrical industries than any other one

cause, as to them may frequently be traced the accidents to life and property and the commercial failure of many installations which in the past have caused a serious public distrust, hard to overcome. A knowledge of the proper systematizing and book-keeping to be used in electrical operations is also essential to the engineer. In a railway or light plant the forms and records used should be such as will show at a glance how each part of the system is operating. With such records any extravagance may be immediately checked. The last term of the Senior year is largely devoted to the line of study suggested and not only are lectures given but the student must do original investigation in compiling statistics, devising forms, etc.

Inspection trips are taken by the upper classes to points of electrical interest when it is felt to be of advantage to the College work.

The last term of the Senior year is devoted largely by each student to the preparation of his Graduation Thesis, which must be original work. The subject selected is such as will be of direct use in his chosen specialty.

The Summer School, which was established in 1894 for two weeks at the beginning of each of the three summer vacations, furnishes time for much laboratory and draughting-room work, giving a facility in practical manipulation not possible within the limits of the four years' regular course. The term between the Junior and Senior years is given largely to the design and construction of electrical machinery.

In the engineering library, readily accessible to the student, are the books most needed for reference in the different lines of study. The leading electrical periodicals of this country and Europe are upon one of the reading room tables. As it is impossible for a student to find time to read the valuable articles in all the journals, the instructors select and mark such as they deem most important. Each student in the Senior class selects one of the marked topics and makes himself familiar with it. A portion of one day of each week is set aside for the consideration of these articles; the students meeting with the instructors and presenting the subjects they have chosen. This presentation is followed by an informal discussion of the points developed. This work is considered one of the most important features of the Senior year as it brings the student into direct touch with the engineering world.

Draughting and Design.

Draughting practice is considered so important a part of the training of the engineer that a large amount has been incorporated in the Electrical Engineering Course. This practice begins with

the Freshman year and extends more or less continuously throughout the four years. The electrical machine and installation design begins with the Junior Summer School and is pursued somewhat in the following manner: The student is first required to design a direct current machine to be arranged for some specific duty designated by the instructor, and must make all the calculations and detailed drawings necessary for its construction in the shop. He then similarly designs an alternator; and lastly, he takes up the transformer, making a number of calculations for apparatus to be used for different purposes, such as for incandescent lighting at different ratios, for arc lighting, and electric welding. During the work he is given numerous references to standard works, catalogues, and the machines to be found in the College equipment.

Some designing is also done of instruments, arc lights, etc. In installation design the students are required to make complete designs for electric plants, as designated by the instructor. Thus, if a student is assigned a street railway plant to operate in some nearby town, he first looks over the ground and decides on the position of the power house, taking into account the price of real estate, the facilities for fuel and water, and the position on the line. He next takes up the power plant equipment, which includes the power, type and arrangement of the boilers; the coal storage and transportation and the disposal of the ash; the type, power and arrangement of the engines, condensers, pumps, etc., and the piping; the type, power and arrangement of the generators, and the general dimensions and construction of the station building. This work must be done so that it will show evidences of economy in operation and construction, and the proper safeguards against accidents, or the instructor will not accept it. The switch-board must be designed with suitable instruments, and to give the most flexible and facile control possible under the general conditions. The car sheds must be designed with satisfactory trackage, repairing pits, motor transporters, cranes, etc. A roadbed and track rail must be determined upon which will give good service with a minimum of repairs. And, finally, the overhead and underground wiring must be laid out with the utmost care, for not only does good operation depend upon this portion of the equipment, to a large extent, but it is also liable, if poorly arranged to be a source of constant trouble and danger. Motor equipments suitable to the conditions to be encountered must also be selected. In addition to the design the student is required to make complete specifications and estimates for the plant. This work requires all the preliminary training of the course, hence it is placed in the latter part of the Senior year.

Laboratory Practice.

The Department has been endeavoring each year to gather together such apparatus in the laboratory, and to put such notes in the hands of the students as will enable them to do thoroughly good work. We believe with the lines of experiment now covered, and which conform as nearly as possible to the modern ideas of what an electrical engineering laboratory course should consist, that the result attained is not unsatisfactory. To obtain satisfactory results in the laboratory training requires much more attention and preparation in the way of facilities than appears at first glance. Electrical measurements, when carried out with care and the use of the best instruments can be made to give exceedingly accurate results. Such is probably more the case than in similar measurements of any other form of energy. This possibility of attaining experimental results with almost mathematical accuracy affords an opportunity for most valuable mental training.

Careful consideration is given to making the laboratory testing practical. A student who makes a test or measurement without understanding its practical bearing loses much of its value, and is likely never to be able to make the applications which will be called for when he enters his profession. For instance, he may make measurements of high resistance or of mutual inductance and yet not understand any better how to apply the measurements in practice than a person would be able to apply the principles of calculus who had merely studied the formula without working the examples. In order to obviate such disadvantages in the electrical engineering laboratory, the conditions are made as similar as possible to those found in practice; the student tests the insulation resistance of a cable or light mains, or finds the mutual inductance of a transmission line. Not only are the principles and phenomena of electricity thus exhibited to the student much as they will be in later life, but he is also required to do the work from the very beginning himself. If he is to make a certain test upon a dynamo the instructor indicates what portion of the laboratory notes and what references he shall study, giving him aid on points that are not clear. He then has the necessary apparatus placed at his disposal, which he must connect up for himself, the instructor supervising sufficiently to prevent serious accidents. If the student makes wrong connections or uses wrong methods in carrying out the test he is expected to find out the trouble for himself.

One of the things that we consider most important is that the student shall learn to overcome the difficulties that arise in his work, and to this end he is carefully impressed with the importance of depending upon himself. As an example; two of our students were last term calibrating a new dynamometer for different frequencies.

They read up everything they could find upon the subject, and were permitted to use whatever apparatus they deemed necessary. One difficulty after another was encountered and overcome. Several times after they were well under way they found changes necessary which compelled them to begin over again. In one instance after they had everything fixed to their satisfaction and had obtained the necessary observations, something appeared to be very wrong in the final results. After examining their apparatus carefully they found that a lamp-board which they were using in connection with one of the instruments as an induction-less resistance, contained such a large self-inductance that the results were useless, and it was necessary to start again. The completion of that one test, with the greatest accuracy possible under the conditions, on their own responsibility gave the two students a clearer idea of the requirements of electrical testing than would be gained by the work of a whole term, were all difficulties smoothed out by those in charge. The other method of doing work of this nature I observed in the laboratories of one of our well known universities. In these laboratories the apparatus is all fully connected up through switch boards and all the connections with the instruments for the experiments are made by the instructors. When a student is assigned a given experiment he finds everything in readiness to make the observations. All the details have been so carefully arranged and tested for him that it is impossible to have any trouble in obtaining the correct results. When, during the test, it is necessary to have a connection changed or a switch thrown the student is not permitted to make the change himself, but must call upon the switchboard attendant to do it for him. Such a method may give the student a theoretical knowledge of the performance of dynamo electric machinery, which would be satisfactory to the mathematical physicist, but is entirely inadequate in training for a man who intends to deal practically with such machinery or who wishes to carry on practical investigation in electrical subjects.

After the student has completed a test he is required to present to the laboratory instructor a written report, which consists first of a description of the apparatus used; second, an outline of the method employed; third, the data observed; and fourth, the results obtained. He is also expected to make a note of the precautions which were taken to prevent error. With this written report he also presents a diagram of the connections of the apparatus and a graphical representation of the observations or results. If this report is found satisfactory, he is permitted to enter upon another experiment, but if not, he is kept at the former until it is mastered. The student also makes a permanent record of his work, which is

his own property, but which he turns in at the end of each session for inspection.

At present there are no laboratory manuals which satisfactorily cover the ground that should be gone over by a student pursuing a strong course in electrical engineering, and therefore the corps of instructors in the Department have been collecting together in the form of notes the best material that can be gleaned from available sources. These notes are placed in the hands of the students as a basis for their work, though in addition to the notes they are expected to read carefully the original articles, to which they are referred.

An outline of the experiments, which run parallel with the technical portion of the Electrical Course, may be of interest and is inserted as follows:

Assembling and caring for primary cells.

Efficiency and variation of potential of primary cells.

Resistance and electromotive force of primary cells.

Assembly and caring for secondary cells.

Curves of charge and discharge for different rates, recuperative power, etc., of the secondary cell.

Efficiency of secondary cells.

Calibration of a voltmeter by standard cells or the balance.

Calibration of an ammeter by the balance, voltameter, or standard cells and resistance.

Calibration of a wattmeter by the balance or voltmeter and ammeter.

Calibration of alternating voltmeters, ammeters and wattmeters for different frequencies.

Calibration of recording ammeters and wattmeters.

Horizontal, spherical and mean candle-power of an incandescent lamp.

Curve of candle-power for different voltages in the incandescent lamp.

Special tests on the life of incandescent lamps.

Efficiency of incandescent lamps.

Vacuum tests of incandescent lamps by the induction coil and heating.

Assembling and connections of the arc lamp.

Regulation of constant potential and constant current arc lamps.

Candle-power of the arc lamp.

Efficiency of the arc lamp.

The assembling, connections and operation of dynamos.

Magnetization curve of a dynamo.

Partial magnetization curves of a dynamo.

External characteristic curves of externally excited, shunt, series, and compound dynamos.

Armature characteristics of dynamos.

Magnetic distributions curves of dynamos, loaded and unloaded.

Loss line and resistance line of a dynamo.

Leakage coefficient of a dynamo.

Determination of the compounding for a dynamo.

Loss of pressure due to armature self-inductance and reactions in a dynamo.

Separation of losses in a dynamo.

Efficiency of a dynamo by stray load, Hopkinson, Brackett cradle, and brake methods.

Determination of the number of lines of force passing through a dynamo armature.

Relation of speed to pressure in a shunt dynamo.

Heating and shop tests of a dynamo.

Connections and operation of a motor.

Relation of speed to excitation, load, and pressure in a motor.

Measurement of alternating pressure and current.

Measurement of self-inductance using an alternating current, and by comparison with a standard resistance, capacity, or self-inductance.

Use of the secohmmeter in the preceding measurements.

Measurement of a capacity by direct deflection, divided charge, comparison, etc.

Measurement of the impedance of a condenser.

Effect of a condenser across the terminals of an alternator or transformer.

Measurement of power in an alternating circuit by the wattmeter, electrometer, three instruments, and split dynamometer.

Hysteresis, permeability and magnetization curves of a magnetic specimen by the permeameter.

Measurement of the angle of lag in an alternating current circuit.

The assembling, connections, and operation of an alternator.

Magnetization curve of an alternator.

External characteristic of an alternator, on inductive and non-inductive loads.

Loss line in an alternator.

Leakage co-efficient of an alternator.

Curves of current and pressure in alternator using a contact-maker and other methods.

Self-inductance and reactions in an alternator armature.

Regulation of an alternator.

Separation of the losses in an alternator.

Synchronizing and the operation of alternators in parallel.

Efficiency of alternators by the brake, Brackett cradle, Hopkinson, Mordey, rated motor, stray load, and motor generator methods.

Heating and shop tests of an alternator.

Measurement of mutual-inductance using an alternating current

and by comparison with capacity, self-inductance, or standard mutual-inductance.

The connections and operation of a transformer.

Magnetization curves of a transformer.

External characteristic of a transformer.

Iron losses of a transformer.

Separation of the iron losses in a transformer.

Copper losses in a transformer.

Magnetic leakage in a transformer.

Test for regulation of a transformer.

Self-inductance of the primary and secondary of a transformer.

Mutual inductance of a transformer.

Power-factor of a transformer.

Transformer curves of pressure and current.

Efficiency of a transformer by stray load, wattmeter, split-dynamometer, three instruments, etc.

Heating and shop tests of a transformer.

Connections and operation of a synchronous motor.

Relation between armature current and excitation in a synchronous motor.

Relation between the motor pressure and the impressed pressure of a synchronous motor.

Maximum load of a synchronous motor.

Connections of polyphase circuits to light mains.

Measurement of power in two-phase circuits by one and two wattmeters.

Measurement of power in three-phase circuits by one, two and three wattmeters.

Connections and operation of induction motors.

Iron and copper losses in induction motors.

Regulation of induction motors.

Starting torque of induction motors.

Relation between slip and load in induction motors.

Power-factor in induction motors.

Efficiency of induction motors by transmission dynamometers and stray load methods.

Specific conductivity tests and the conductivity of line wires.

Capacity of a cable by direct deflection, Gott's method, etc.

Insulation resistance of cable by direct deflection, bridge, leakage, etc.

Break down insulation test.

Location of a fault by the overlap, loop, and other methods.

Location of a cross.

Voltmeter methods of determining the insulation and faults in a line.

The use of the voltmeter and ammeter for testing purposes.

Resistance of screw contacts, of a brush on a commutator, of single armature coils, etc., by fall of potential method.

Electric welding by Thomson, water pail and arc welders.

Experiments covering the principal phenomena in electrolytic action.

Electrolytic separation of metals and electroplating.

Measurement of current, self-inductance, etc., in telephone circuits.

Complete tests of the College light and power plant and other installations.

This list comprises under general headings our principal laboratory course. In a number of cases the headings include several allied tests or experiments, while in a few others the work has already been partiality done in a previous experiment. For instance, if magnetic leakage has been carefully investigated in the dynamo it is scarcely necessary to spend much time upon it when dealing with the alternator. I do not append a full list of the experiments in electrolytic work as this course is still in a formative stage, and I should prefer waiting until the course and the laboratory equipment are more fully developed before going into a detailed description. The aim is to arrange an efficient course covering the deposition of metals from their crude state, electro-plating, and allied industries with the necessary chemical work accompanying such experiments. We are also extending our experimental work which relates to the transmission of electrical energy and its development into the mechanical form. The motors which drive the shops and fans are exceedingly useful in this work as they are in actual commercial service, but to extend the work and include electric traction an experimental electric railway is now in process of construction.

The following laboratory reports of experiments will probably give a better idea of the nature of the laboratory practice than any explanation that I could make:

REPORT

By ..... Class, '95. Date May 15, 1894.

Object:—The determination of the magnetization and permeability curves of a specimen of white cast iron made at Bellefonte, Pa.

Apparatus:—The Hopkinson Permeameter, Ballistic Galvanometer x-35, resistance boxes Nos 1 and 2, and a 15 lamp regulating resistance board. The Permeameter has 1,500 turns in its magnetizing coil and 300 in its movable coil. The resistance of the galvanometer was 1,000 ohms at 21.8 degrees C. and one microfarad condenser charged with 1.44 volts gave a deflection of 145 m. m. on a scale one meter distant. The test piece was 14 inches long by one-half inch in diameter and divided into two sections.

Method:—The test pieces were inserted through the yoke and the two coils and the magnetizing coils excited increasing amounts. At each excitation the test piece was withdrawn slightly and the deflection of the galvanometer, caused by the movable coil jumping out and cutting the lines of force noted. The strength of the magnetizing field set up in the fixed coils is:—

$$H=\frac{4\pi n c}{10 l}=\frac{4\times 3.1416\times 1500}{10\times 41.37}=45.563$$

The constant of the galvanometer is:

$$K=\frac{P E}{10_6 \cdot \subseteq}=\frac{1.44}{10^6 \cdot 145}=.000,000,009,924$$

The induction through the test piece per sq. cm. is:

$$B=\frac{10^8 R K \subseteq}{A n.}=\frac{10^8\times .000,000,009,924\times R\times \subseteq}{300\times 1.266}=.002,606\, R \subseteq$$

The permeability of the specimen is found for different inductions from the formula:

$$\mu=\frac{B}{H.}$$

Table of Results.

No.	B.	H.	M.
1	355	3.65	97.2
2	506	4.56	110.9
3	706	4.76	148.4
4	1,202	6.52	184.4
5	2,221	10.34	214.8
6	3,679	17.50	209.2
7	4,233	22.78	185.8
8	5,150	36.73	140.2
9	6,167	58.68	105.1
10	6,642	73.13	93.6
11	7,682	108.9	70.5
12	8,257	150.71	58.1

We hand in the observations on a separate sheet and also the curves of magnetization and permeability.

REPORT.

By .....Class of '94. Date April 20, 1894.

Object:—Tracing alternator current and pressure curves.

Apparatus:—The LaRoche 5 K. W. alternator was used, with the two-phase armature. The coils of this armature are of the pan-cake pattern and cover almost the entire circumference. The coils of the two phases are set side by side. The contact maker is permanently fixed to the machine. The other instruments used were a Thomson Multicellular Voltmeter, and two one-microfarad standard condencers. Non-inductive resistance was used for absorbing the load.

Method:—The alternator was run at no load constantly at the rated speed and excitation, and readings were taken on the volmeter when the contact maker was set at 18 equidistant positions on one pitch. A condenser was used with the voltmeter in order to increase the capacity. As the range of the volmeter is from 60 to 150 volts, it was necessary in getting the lower and higher readings to place a second condenser

in series with the one mentioned and charge it with a known potential from the power mains. This added or substracted, according to the connections, the known potential from that desired. In this way all readings were brought to the most sensitive point of the voltmeter scale. The series of readings was taken from each phase unloaded and then a similar set was taken with the machine loaded. Special precautions were taken to keep the speed and excitation constant.

Observations.

Number of observations.	First Phase.		Second Phase.	
	Unloaded.	Loaded.	Unloaded.	Loaded.
	Effective Pressure.			
	123	108	145	130
	Instaneous Pressure.			
1	+ 86	+ 80	+136	+105
2	+140	+117	+ 76	+ 48
3	+150	+136	— 41	— 23
4	+163	+142	— 68	— 90
5	+168	+138	—134	—138
6	+150	+120	—172	—160
7	+112	+ 74	—180	—167
8	+ 57	+ 29	—185	—168
9	— 16	— 36	—170	—150
10	— 68	— 78	—134	—100
11	—117	—116	+ 80	+ 52
12	—148	—138	+ 32	+ 12
13	—161	—146	+119	+ 82
14	—168	—138	+143	+113
15	—150	— 94	+162	+187
16	— 72	— 50	+175	+168
17	— 16	— 20	+175	+167
18	+ 24	+ 18	+160	+142
19	+ 86	+ 81	+130	+105

The curve shows a differential action on the armature coils and poor magnetic distribution.

REPORT.

By .....Class of '96. Date February 29, 1896.

Object:—The Determination of the curve of magnetization of a transformer.

Apparatus:—The current was obtained from the lighting mains. A 10 lamp rheostat, low reading ammeter, milli-voltmeter as a ballistic galvanometer, and a standard resistance box were connected to the primary and secondary of the transformer as shown in the figure.

Method:—The lamp-board and ammeter were put in circuit with the primary and the current from the mains was varied by changing the combinations on the lamp-board. The milli-voltmeter was used as a ballastic galvanometer in the secondary circuit, such extra resistance being inserted as was necessary to make the deflections readable. The deflections obtained when the primary circuit is made or broken are proportional to the magnetization when multiplied by the resistance in the secondary circuit.

Data and Results:—Under Milli-volmeter Readings are given the average of six observations taken for each current value.

Resistance.	Primary Current.	Voltmeter Readings.	Voltmeter Readings × Resistance.
0	.025	.0228	.2052
0	.023	.0230	.2670
0	.040	.0362	.3258
0	.043	.0445	.4005
0	.045	.0542	.4878
0	.057	.0750	.685
50	.080	.0166	.979
50	.115	.0245	1.446
50	.180	.0375	2.213
50	.390	.0550	3.245
50	.650	.0615	3.629
50	.800	.0653	3.823
50	.890	.0700	4.130
50	1.000	.0733	4.325
50	1.100	.0763	4.502
50	1.150	.0770	4.543
50	1.180	.0790	4.661
50	1.200	.0787	4.463
50	1.210	.0800	4.720

REPORT.

By .....Class of '96. Date February 25, 1896.

Object:—To determine transformer efficiency by the stray loss method.

Apparatus:—The LaRoche alternator furnished the power. A two K. W. Westinghouse transformer was under test. The hundred volt coil of the transformer was connected to the alternator with a wattmeter in circuit. A 1,200 volt voltmeter was connected across the terminals of the 1,000 volt coil, which in this case was used as the secondary. A dynamometer was placed in the secondary for the C^2R losses.

Method:—When the alternator voltage was brought up to the required point on the voltmeter we read the wattmeter. This gives the iron losses. In order to measeure the copper losses the secondary was short circuited through a dynamometer and the pressure regulated to give the current desired. The wattmeter readings now give the C^2R losses. In the first measurement the current was so small that the copper losses could be neglected and in the latter the magnetic losses may be neglected. The efficiency is:

$$U=\frac{W}{W+I+C^2R}$$

Where U is the efficiency, W the watts given out, C^2R the copper loss, and I the iron loss:

Data:—For iron loss:

Watts.	*Volts.*	*Speed.*
86.1	1010	1400
85.9	1007	1400
86.0	1010	1400

For copper loss:

Watts.	*Current.*	*Efficiency.*
95	20.08	91.70
82	17.68	91.32
66	14.57	90.55
75	15.48	90.59
60	13.71	90.37
55	13.19	90.34
30	9.47	89.03

Curves of efficiency accompany this report.

REPORT.

By .....Class of '96. Date January 23, 1896.

Object:—To determine the discharge curve of a five cell chloride storage battery and its internal resistance.

Apparatus:—The apparatus used was a 0-15 voltmeter, a 0-100 ammeter, a variable resistance, and a watch. The instruments were connected as shown in the sketch.

Method:—We were to find the curve at a discharge rate of 25 amperes, with the cells in series. The cells were connected up through the ammeter and variable resistance so that the resistance could be varied to keep the current at 25 amperes throughout the test. At intervals of five minutes the voltages were read. From the results the curves were plotted with time as the abscissas and volts the ordinates. To determine the internal resistance, the voltage across the terminals when on open circuit was taken and then on closed circuit. The loss, or difference between the two, divided by the current flowing equals the internal resistance of the battery.

Data and results:—Voltage on open circuit=10.72.
Voltage on closed circuit=10.20.
Current flowing (amperes)=25.00.
Internal resistance, five in series=.0208 ohms.
Internal resistance, one cell=.00416 ohms.

Discharge curve readings:

Amperes.	Volts.	Time P. M.
25.8	10.20	2–05
25.0	10.20	2–10
25.0	10.20	2–15
25.0	10.20	2–20
25.0	10.20	2–25
25.0	10.20	2–30
25.0	10.19	2–35
25.0	10.16	2–40
25.0	10.14	2–45
24.8	10.12	2–50
25.0	10.10	2–55
25.2	10.10	3–00
25.2	10.10	3–05
25.1	10.09	3–10
25.0	10.07	3–15
25.0	10.04	3–20
25.0	10.02	3–25
25.0	10.00	3–30
25.1	10.00	3–35
25.0	9.99	3–40
25.0	9.98	3–45
24.8	9.96	3–50
25.0	9.92	3–55
24.4	9.90	4–00

REPORT.

By ..... Class of '95. Date .....October 13, '94.

Object:—Determination of the losses due to armature reactions in a direct current dynamo.

Apparatus:—The machine to be tested was the 3 K. W., 100 volt, shunt wound United States dynamo. A Weston low range ammeter was in the field circuit, and also a Weston ammeter and voltmeter were in the external circuit. The portable tachometer was used for measuring the speed.

Method:—The machine was driven at a constant speed of 2,025 revolutions per minute. The fields were separately excited from the College light mains which gave constant current. An external circuit was arranged by means of resistance boxes so that several hundred ohms could be introduced into the circuit. Eighteen observations were taken, at small intervals, from no load up to 33.2 amperes. A curve, using the observed currents as abscissas and the voltages as ordinates, is handed in with this report. The line showing what the voltage would have been had there been no reaction is gotten from the formula e=E—CR, where E is the voltage at no load, C the current, R the armature resistance and e the ordinate required. The difference in the ordinates of the two curves gives the desired loss of electro-motive-force due to armature reactions.

Observations:—The resistance of the armature hot was found to be .21 ohms.

Speed.	Volts.	Amperes.	Reaction loss in volts.
2025	106	0	.0
"	105	.74	.842
"	104	1.60	1.66
"	102.5	3.05	2.86
"	101	4.55	4.05
"	100.5	5.25	4.40
"	100	6.45	4.65
"	99	7.70	5.38
"	98.5	8.03	5.81
"	98	9.00	6.11
"	97.5	10.00	6.40
"	96.5	11.58	7.07
	96	12.92	7.29
"	95.5	14.10	7.54
"	95.5	14.00	7.56
"	92	26.00	8.75
"	91.2	28.02	8.92
"	91	33.02	8.07

Our equipment has improved more during the past year than during any previous year in the life of the Department. The Executive Committee last spring assigned to the Department, for laboratory purposes, three large connecting rooms in place of the cramped quarters previously occupied. The electrical apparatus has been disposed in these rooms in such a way as to add very materially to its utility. The wiring of the rooms is such that ready connection can be made to any piece of apparatus in any room or with the light and power station. During the year a Weston engine was purchased and installed to be used as a driver in connection with a forty horse power motor, which receives energy from the College plant dynamos. This engine almost doubles our capacity for work in the dynamo testing laboratory and enables us to pursue many lines of experiment before impossible. The Department has also under way the construction of an experimental electrical railway (spoken of above) about a mile in length, to be used as a portion of the laboratory equipment. The management of the Bellefonte Central Railroad kindly granted us the use of their road bed for this purpose. A branch of the railroad runs directly into the court of the Engineering building, thus lending an exceptionally

favorable opportunity for our work. The White-Crosby Company, the senior member of which is a graduate of this College, presented us with a large portion of the line work, and other companies have offered us the remainder of the apparatus at much less than half cost price. At the present time almost a mile of the line work is installed. A good substantial cable car body has been purchased which will remodel into a testing car to suit our purposes admirably. It is the intention to obtain the power for this road from the College plant until a standard railway generator can be had. In addition to these changes in our equipment, a number of new instruments have been obtained, which were found necessary in carrying on the advanced work of the department.

The following gives a general idea of the apparatus we are at present using.

Among other things the laboratory is equipped with a standard photometer, with the necessary instruments and adjustments for arc and incandescent measurements; an induction coil arranged for incandescent lamp vacuum testing, a number of direct and alternating current voltmeters, ranging in scale readings from .0001 to 1200 volts; a number of direct and alternating current ammeters ranging from .0001 to 100 amperes; electro dynamometers, Wattmeters, direct reading and recording, also recording amperemeters; D'Arsonval and other galvanometers, both ballistic and light movement, furnished with lamp scales and placed in box rooms, about 4 feet by 4 feet, especially designed for the purpose; standard condensers; standard resistance boxes ranging from one of twenty-two hundred and twenty-two ohms to one of one million ohms. Wheatstone bridges, including a standard with five dials, the first reading tenths and the fifth ten-thousandths. The resistances are furnished with certificates of accuracy to one-fiftieth of one per cent. and have mounted thermometers or compensating temperature coils. There are also standard coils for calibrating purposes, a permeameter of the Hopkinson type, a secohmmeter, a Thomson centi-ampere balance with resistance arranged for reading voltages or small currents; a large number of primary cells; a chloride storage battery; charge, discharge, commutating keys, etc., etc.

The dynamo room is situated near the testing room and contains the following: A forty-horse power constant speed motor, which is used in driving the other apparatus, in connection with a forty horse power Weston engine; a fifteen horse-power Thomson-Houston street railway motor; a Maxim five-arc light dynamo; a Weston ten-arc dynamo; a two hundred light Brush dynamo; a Westinghouse one hundred incandescent light dynamo; a five hundred light, one thousand volt, Westinghouse alternator, fitted with a voltmeter, ammeter and compensator; a La Roche one hundred light alternator,

fitted with one and two phase armature; a one horse power two-phase Stanley alternating current motor with transformer and condenser; a four-horse power multipolar Sturtevant fan motor with a steel blower; a number of transformers of ratios 1-10 1-20; a special 10,000 volt transformer; an alternating current welder and pail welder; and a complete Brush arc light plant, with dynamo lamps and a continuous current motor. The machines are connected by counter shafting so that they may be run in any combination desired. A special bank of transformers is arranged for getting high potentials for break down insulation tests. There are also poney brakes, a Brackett cradle dynamometer, regulating and load wire and water resistances; incandescent lamp boards, one of which is so arranged that it may receive at the proper lamp potential from .1 to 100 amperes and dissipate 11,000 watts; a contact-maker, pilot brushes, switchboards, tachometers, etc.

In addition to the special electrical engineering equipment the College light and power plant is used for illustrative and experimental purposes. The plant contains among other things useful in teaching electrical engineering: Three Edison dynamos of one hundred and twenty thousand watts total capacity, a switchboard equipped with a number of Weston and Edison ammeters, voltmeters and potential indicators; also several types of rheostats. This station supplies energy to nine motors, multipolar and bipolar, of about eighty horse power, total capacity, which operate the shops and ventilating fans; also energy to about eleven hundred and fifty incandescent lamps for lighting the College buildings, and a number of arc lamps on the campus. Specimens of wiring, such as tunnel, underground cable, pole, concealed, molding and open work are exhibited in the plant. This is, so far as we can discover, the largest and most diversified plant in commercial operation in any college in the country. These lists do not include the apparatus used in teaching elementary electrical and magnetic measurements, this part of the electrical work being done by the Department of Physics. For a description of the apparatus for this I would refer you to the descriptions and illustrations given in the report of that Department. Where it is found expedient the Departments of Physics and Electricity call upon each other for special apparatus, thus enlarging the facilities of both.

Department Needs.

Although the work being done by the Department is rigorous and thorough in the lines that have been developed, there is yet much to be desired in the way of facilities for extension in the old and in new directions. Already we are beginning to feel that more room could be put to valuable use in carrying on many lines of in-

vestigation, and I believe that it is not going too far to ask you to seriously consider the question of adding a wing to the Engineering building or of devising some other means of procuring us more ample quarters.

The State of Pennsylvania, with its vast manufacturing and mining interests has probably a greater capacity for utilizing electricity to advantage than any other State in the Union, and it would seem no more than right that this State should have systematic investigations made, looking to the discovery of new and better methods for such utilization. From the report of the Pennsylvania Commission on Industrial Education, of which you were chairman, I gather that in your opinion appropriations judiciously made by a government for training workmen scientifically in industrial pursuits and for granting facilities for the improvement of industrial processes have been richly rewarded. On this basis I make a plea for an appropriation to the Department to carry on such investigations in the applications of electricity to the manufacturing industries. At present such work is done by the experts of manufacturing companies and by college men in the unsatisfactory intervals of their regular duties, usually without the needed facilities.

I also earnestly request an appropriation for the benefit of our library. At present we have the periodicals of greatest worth upon our library table and the reference books absolutely essential to our work, but our equipment is certainly weaker in this direction than in any other. Several hundred dollars could be expended in adding to our list of technical books, with great benefit to our students.

We need a great deal of new apparatus. There should be representative equipments of all commercial types of railway apparatus for use in connection with our experimental electric railway; there should be alternating current apparatus, including poly-phase machinery, covering the entire field; there should be a large increase in the number and variety of our measuring instruments; there should be a completely equipped electrolytic laboratory; and there should be all types of primary and secondary batteries. In fact our laboratories should not only be capable of furnishing a strong course to undergraduates, but should be so equipped that any lines of investigation allied to electrical engineering could be carried on, and so that any person desiring to become familiar with any kind of electrical apparatus could do so by entering our laboratories and library. I think it will be conceded that it is the duty of the State College of Pennsylvania to furnish such facilities to the people of this State.

I would call your attention to the following list as indicative of what is needed by the Department to make it worthy of the great interests it represents:

Library,	$1,200 00
Railway equipment,	2,500 00
Single-phase alternating current apparatus,	2,000 00
Poly-phase apparatus,	5,000 00
Arc and incandescent lighting apparatus,	1,500 00
Instruments,	6,000 00
Batteries,	2,000 00
Electrolytic laboratory,	3,000 00
For investigation,	10,000 00
	$33,200 00

Light and Power Plant.

Electric Light.

During the past year the Botanical Building, the Bellefonte Central Railroad Station, the Beta Theta Pi Chapter House, a campus residence, a number of new lights in the main building, and four new arc lights on the campus have been added to the College light plant.

This makes the number and distribution of the lights as follows:

Incandescent Lamps.

		Number.	
Armory,		80	
Engineering building,		67	
Railroad station,		15	
President's residence,		68	
Professor's residence No. 1,		37	
Professor's residence No. 2,		37	
University inn,		203	
Fraternity House,		58	
Main building, basement,	28		
Main building, 1st floor,	90		
Main building, 2nd floor,	56		
Main building, 3rd floor,	66		
Main building, 4th floor,	56		
Main building, 5th floor,	97		
Main building, chapel,	71		
		456	
Cottage,		89	
Botanical building,		36	
Total,			1,146

Arc Lamps.

Campus,	14	
		14

In addition to these there are about 175 incandescent and 7 arc lamps used in the Electrical Laboratories for experimental work.

The motors is circuit are:

	Number.	Horse Power.
Shops—Turning room,	1	15
Shops—Forge room,	2	8.5
Shops—Pattern room,	1	20
Shops—Machine room,	1	10
Shops—Foundry room,	1	5
Mining laboratory,	1	3
Engineering building ventilation,	1	2.5
Main building,	1	15
Electrical laboratory,	1	40
Total,	10	119

The insulation resistances of the wiring of the several buildings as shown by the last set of measurements are:

	Megohms.
Cottage,	10
Botanical building,	4.07
Armory,	10
Residence No. 1,	10
Residence No. 2,	10
Engineering building,	4.02
Main building to 3rd floor,	10
Main building from 3rd floor up,	5.18
Fraternity House,	10
University inn,	10
President's residence,	10

The 10 indicates that the apparatus which was sensitive through ten megohms showed no deflection.

At the beginning of the year the main College building was completely rewired. The Electrical Inspector of the Underwriter's Association has inspected the new work that has been done during the year and has given it his approval.

In closing I desire again, Mr. President, to express to you my appreciation of the active assistance you have continued to give the Department in conjunction with the Board of Trustees.

Respectfully submitted,

JOHN PRICE JACKSON,
Professor of Electrical Engineering.

State College, Penna., January 1st, 1897.

VI.—ENGLISH AND RHETORIC.

To the President:

Sir:—The Department is now thoroughly organized and the work of the past year has been a decided step in advance. The increased instruction in the English Classics which has come with the reorganization of the Preparatory Department, and the new arrangement for rhetoricals made possible by the addition last year of a thoroughly competent instructor, have already made themselves felt. The students have been especially attentive and appreciative and in many cases have shown an enthusiasm for their work.

It has been the constant aim of the Department to make the study of English as practical as possible. What the technical student needs is not alone the theory of rhetoric and the general principles of literary criticism, but the ability to express himself easily in clear and forcible English. He is supposed upon entering the Freshman class to have a good foundation already laid in English grammar and composition, and during his first two terms he is taught, with Hale's Constructive Rhetoric as a guide, to apply himself to actual work in English Composition. He is given a few precepts and much practice. The motto "we learn to write by writing" is kept constantly before him. A little later, carefully selected specimens of exposition and argumentation are placed in his hands for analysis and criticism, and still later he is given a short course in Old English; but, throughout his sojourn in the Department, he is required constantly to furnish written work to be criticized and amended.

It is a constant source of regret that the Engineering students, who form by far the larger percentage of the undergraduate body, receive no instruction in English after the Freshman year save that given in the Sophomore and Junior forensics. The crowded state of the curriculum seems to render this state of affairs, for the present, unavoidable; but it is to be hoped that in the near future a way may be opened whereby these students may receive some little instruction in English Literature. The students of the other courses, however, have ample opportunity for work in this direction, and, with the parallel courses in criticism and literary history which have been opened during the present year, it is now possible for the student to specialize in these branches to a considerable extent.

The question of all others that is at present most troubling the

Department is how to deal with the marked lack of preparation in English shown by nearly all who enter the college. While this is largely the fault of the common schools of the State and is, therefore, in its very nature, somewhat beyond our power of complete control, it is, nevertheless, a question that deserves your most careful consideration. The matter of inadequate preparation seems to affect the English Department more seriously than it does any other. A student may enter fundamentally weak in one of the other required branches, be conditioned in the subject, and by hard and systematic work may not only remove his condition but may take in time even a leading position in the class pursuing this branch. But the student entering fundamentally weak in English cannot in a few months make himself whole in the subject, try as he will. He may perhaps become intimately acquainted with the required classics and know by heart the rules of the English grammar, yet it has been shown many times that, even having these to perfection, he may still be radically weak in his use of English. It is of small use to condition such a man hoping for improvement in a few months. It has been proved by many observers and many institutions that one who enters college very weak in the essentials of English will leave college proportionally weak in the subject. The cause is not hard to find. To learn to spell correctly, if one has, through defect of early training, failed to acquire this very important accomplishment; to learn to avoid feeble, inaccurate and slovenly constructions, and to express oneself easily, an accomplishment absolutely demanded of every young man who would rise at all above the ordinary level, is the work of years, and it must be learned very largely in the lower schools, or, with rare exceptions, not at all. The college should give the finishing touches, but the foundations must be firmly and broadly laid by the schools. That the schools are neglecting this work is only too evident.

The duty of the Department is not yet perfectly clear on this point. To apply more rigidly the entrance requirements, as many other institutions, notably Harvard, are proposing to do, seems hardly just at present, since it would bar out many who have obtained the best preparation for the college within their reach but who, nevertheless, owing to the defective English instruction in the State schools, have been unable to meet the requirements in this one study. On the other hand, the Department has no alternative but rejection in all cases where the candidate's English is notably defective. Some means should be taken to bring to the schools of the State a sense of their responsibility in this matter and to secure, if possible, more thorough instruction in what is really the most important branch that the English-speaking student can pursue.

In regard to the material needs of the Department we mention first, as usual, the subject of books. The appropriation of last year furnished books enough to supply the most urgent practicum needs but many more could be used with great profit. It is to be regretted that a fund cannot be established to supply the library with all valuable current works and so keep it fully abreast of the times. The Department would ask specifically for $30 for two English dictionaries which are badly needed for class room use.

In conclusion I wish to express my hearty thanks to you, Mr. President, for your valuable counsel and unfailing support, to Mr. Munroe, who has proved an enthusiastic and helpful co-laborer, and to all others who have in any way contributed to the success of the year.

Respectfully submitted,

FRED LEWIS PATTEE,

Professor of English and Rhetoric.

State College, Pa., Jan. 1, 1897.

VII.—GREEK AND LATIN.

To the President:

Sir:—In submitting to you my fifth annual report, I desire to record the good Providence which has guided the work of another year, the constant courtesy and kindness which I have received from you, from my associates in the faculty, and from the students under my care. If there is, anywhere, greater manliness among students, or more of the spirit of helpfulness among faculties, I have yet to find it. Such things ought not to be overlooked even in a purely departmental report such as this.

The specific work of the department has been as good, perhaps, as the average can be in a world where we do not expect to attain any of our ideals. The Sophomore class read the De Officiis in the Winter session. It was their first contact with Ethical studies and their eager interest was heightened by other readings on the subject of Duties from both Latin and English sources. The letters of Pliny followed in the Spring session. These, as being easier Latin, engaged with lighter and varied subjects, gave more pleasure than any thing the class had previously read. Their attention was called to the richness of Epistolary Literature and other examples were presented to them of Latin and English classical correspondence.

Four students had been enrolled in the Sophomore class in Latin up to this time; but in consequence of special schedules, two were unable to continue the course, and, at the opening of this fall session, we were reduced to one. During the session now closing, the class has read selections from the Histories of Tacitus and evidently—as shown by the examination—with profit and enjoyment.

The Freshman class of the Winter and Spring sessions numbered only three, but our enrollment for the term now closed was eleven. This is nearly three times the number that was enrolled in the Freshman class of four years ago, and, in fact, the number in the department is exactly doubled.

The work of the Freshman class for the Winter was in Livy, as scheduled. This was followed by Virgil as usual. The incoming Freshmen have read Sallust during the session now closed.

Almost without exception, work has been done well and honorably, showing a gradual gain in scholarship, in ability to read and enjoy Latin. Unfortunately, there are always a few students who furnish painful exceptions and on whom kindly warning or open rebuke

makes no apparent impression. But every good teacher is, in his profession, to come in contact with these listless and sometimes—I am sorry to add—dishonest students. It is a pity that too many of us find them a problem which we have not the knack to solve.

Courses in Greek and Latin were carefully constructed last year and there seems no need of varying from them in any particular. It will probably be necessary from this time forth, considering our teaching force, to make the Latin of the Classical and the Latin Scientific courses synonymous, and also to make the same requirements for entrance in Latin to each of these courses. If our teaching force were larger it would be wise to have instruction in each of these courses separate and distinct, as I think that students who are studying Latin with reference to the help they can derive from it in biological, medical or other special studies should not have the same sort of instruction as those who are studying Latin and Greek for the literatures.

The standards set in our last catalogue are high and, with some few additions, will be equal to any in the country. Let us not depart one iota from the requirements thus made. These will demand an equivalent of four years for preparation in Latin and of three in Greek. This amount of time is necessary in order to lay properly the foundations of grammatical study and to secure greater rapidity and exactness in translation. I can imagine that the immediate effect will not be to bring us numbers, but it will enhance, among us, the quality of literary acquirements, it will add tone to English studies and thus perform a doubly needed service. Students, from whatever quarter they come to us, show that the standards in language, whether English, Latin or Greek, are not high enough. It is for us to help raise them, all over the State. Our position makes it possible, yes absolutely obligatory. Let us not fail in our duty.

Even as our requirements for entrance now stand they are not strong enough. We need to add, an elementary knowledge of Latin and Greek mythology and geography, also as much of ancient history as is contained in some good hand-book; so that the student will feel at home in Grecian history as far as to the death of Alexander and in Roman history as far as to the reign of Augustus or Marcus Aurelius.

In this report, I have made no mention of such work as has been done by me in the sub-Freshman class during the past year. This has been in Latin and—I am happy to add—in Greek also, all of which has been performed according to schedule and with good results.

In thus closing more than twenty-four years of consecutive, uninterrupted work as a teacher, twenty years of which have been

spent in Massachusetts and more than four in Pennsylvania, I can truly say that I have never found students who were more kindly, who labored harder, or who gave better promise of making useful and influential citizens, than I have found in this grand Keystone State.

My report as to the needs of this department I have addressed separately to yourself and to the executive committee.

And now thanking you, sir, for your many kindnesses, thanking my co-laborers for their helpfulness and my students for their fidelity,

I am, very respectfully,

BENJ. GILL,
Professor of Greek and Latin.

State College, Dec. 23d, 1896.

VIII.—INDUSTRIAL ART AND DESIGN.

To the President:

Sir:—It has been my desire to extend the field of work in the Department of Industrial Art and Design, and my hope to have it rank as a full-fledged department, extending its influence to all students toward the general cultivation of good taste and an acquaintance with the monumental things of the art world. But in the general scheme there seems to be little place for anything outside of the strictly mechanical, and, wherever the students come under the influence of the department, it may be said to be a mere touch and go of the class-room.

At the inception of the work, the needs of the student, as well as methods and kinds of work, were very carefully considered from the several standpoints and the whole scheme so co-ordinated to satisfy the existing conditions.

The work, if desirable anywhere is sorely needed by our students, who, as a rule, have had no training in that line, and none beyond that of the merest elementary character.

Everyone is ready to add his testimony to the worth of the work in the training of the perceptive faculties; as a useful means of expression; and as a creative force toward a finer, more intelligent appreciation of all good work. Many may go so far as to desire it, but few, if any, feel that it is at all possible to forego any time from the work peculiar to their departments to give place to the work of this.

Originally the practicum in Freehand Drawing and Design extended over a period of two years, four hours per week, but in reorganizing the Preparatory Department exactly one half the time was withdrawn.

While it does not seem wise to drop out any part of the work, you will appreciate the fact that each phase must be more restricted.

In so short a time, it is impossible to train the hand to much skill, but with every change in the phase of work is opened a new world for inspection and investigation; and a quickening of the perceptive faculties is the natural result.

In treating of Applied Design in general class work, we can do no more than touch on the principles of good taste which have been fixed for us by those generally accepted in all times, and the

restrictions placed by materials and methods of manufacture, though we may speak of prevailing fashions or fads connected with some of them.

It is a matter of regret that more may not be done in the use of color, as it is a never failing source of delight, although a tantalizing medium, and helps to prove what infinite variety may be effected by its use, in what appears in outline to be a rather uninteresting design.

In designing for cast or wrought iron it has long been my desire to have the students work with a view to reproducing their designs in metal; and with the co-operation of the Mechanical Engineering Department I believe it could be done, and I shall seek an opportunity to confer with Professor Reber concerning it.

When your attention is called to the fact that in every session we have in our classes students who have failed to get the early part of the instruction by reason of late entrance, you will appreciate the disadvantage to student, instructor and the class in general.

It has not been possible to return to any work in modeling and it seems improbable that any arrangement could be made for general class work, but it is to be hoped that the influence of some work of this kind done by students taking a special course will not fail to be practicable.

In the Fall session we always experience embarrassment in getting a class-room large enough to accommodate the several sections of the Freshman class, as the largest drawing-room of the department is inadequate. This year we were again obliged to seek accommodation elsewhere. Through the courtesy of Professor Ihlseng, and at some inconvenience to him, a drawing-room in the Engineering building was placed at our disposal, though no better furnishing could be provided than the banquet tables which are so wide they absorb much more space than desirable and their fixed palsied habit communicated discomfort to the entire line of students seated at anyone of them.

The results of the work with the Freshman class are, naturally, far from what is desirable; but, in that of the sub-Freshman, much satisfaction may be taken when we consider that the work done there was also under unfavorable conditions.

While I appreciate, somewhat, the difficulty of satisfying the necessary demands from so many sources, I beg leave to urge that some special effort be made for the better accommodation of the Freshman class before the opening of another college year.

A few books, casts and other models have been added to the equipment during the year, and a small amount remains to supply immediate small necessities.

In conclusion, may I ask you to consider, in addition to the foregoing, if not a separate building for the use of the department, at least the advisability of having a gallery furnished with good reproductions of art works, where the general body of our students might be attracted and become somewhat familiar with the great works of art; where exhibitions of students' work could be made and where from time to time exhibitions of a special art character could be given. For a comparatively small sum, if judiciously expended, a collection could be made which would be creditable to the institution, and a treasured possession in the centre of the State, so far from any such influences to be had in the large cities at the two extremes. May I also ask you to consider making provision for a series of lectures on art subjects through the Fall and Winter sessions and free to the public, as well as to the student.

Respectfully submitted,

ANNA E. REDIFER,
Instructor-in-charge.

State College, Pa., January 25, 1897.

IX.—LIBRARY.

To the President:

Sir:—The care of the College Library was intrusted to me in September, 1894. At that time the books numbered 9,054. During the preceding summer these had been entirely rearranged, and the Government documents transferred from the main book room to an apartment appropriated exclusively to their use. The unbound magazines and pamphlets had been properly filed in a small room devoted to the purpose. Other conditions were less satisfactory. Numerous small department libraries existed, each of which was too limited to be of material value, while the whole number of books withdrawn from the main library was sufficient greatly to impoverish it.

Many books waited to be catalogued. No shelf-list existed, and neither the books of the main or department libraries had ever been inventoried. Losses sustained were therefore not ascertainable and the books lost were not replaced.

The condition of the card index was deplorable. Many of the cards had been crowded out of the case and into a table drawer, where their classifications were defined by the strings which tied them together. The system which had weakened the library operated to the disadvantage also of the reading room.

While the Preparatory and the Ladies' departments were more or less liberally supplied with popular literature, the library reading-room afforded only scientific periodicals, the weightier literary reviews, and a few local papers.

Although the present condition of the library is far from encouraging, in the interval of two and one-half years much has been accomplished.

The Government books, nearly three thousand in number, have been reclassified, renumbered and largely recatalogued.

A shelf-list has been made, the books of the department libraries have been inventoried, and losses made good. Although the work on the card index had been, for the most part, excellently well done, some revisions seemed desirable, in order to keep pace with advanced methods which have for their object, to quote from a recent address of Mr. J. N. Larned, "the perfected cataloguing, which opens paths for the seeker from every probable starting point of inquiry, not only to books, but into the contents of books."

To further this object, the index of the English library has been greatly elaborated, especial attention having been given to literary criticism and biography, fields often occupied by student research. Adequate cases have been provided for the cards, and an effort is being made to teach the untrained the true functions of subject and author, analytic and cross reference, and to make the students independent in their use of the facilities provided both by the card catalogue and the literary indexes recently added to the reference library. The work undertaken in this line would have been profitless, had not the books scattered about in various class rooms been brought again into the main library.

Books have been added from time to time, by purchase or by gift, and a monthly bulletin of accessions is published in the Free Lance, the college paper.

The departments of Literature, Modern Language and Psychology have been especially favored, and have reached a vantage ground where their usefulness is assured and their further development confidently expected.

Other departments have been less fortunate.

Few additions have been made in history and mathematics, and the meagre assortment of antiquated books is far from creditable to an institution of learning.

The reading room has been much enriched. The list of periodicals has been increased within the last two years from 37 to 59, and now includes two daily newspapers and many of the leading literary magazines and illustrated weeklies. Binders and newspaper files preserve them from needless wear.

The addition of periodical racks would be of great service in economizing the space, which is becoming constantly more valuable.

Magazine articles of general interest or of especial educational value, are bulletined month by month, and such assistance in research as is within the power of the librarians is cheerfully rendered to all desiring it, whether the subject be "the color of Lowell's hair when he was a boy," or "the position of the centre of the universe."

There is an increasing demand for general reference books, and the supply is still very limited.

The engineering libraries, which occupy a room in the Engineering building, have taken a decided step forward. Additions have been made from time to time, and the books now number 938, of which 350 belong to the Mining department, 342 to the department of Civil Engineering, 223 to that of Mechanical Engineering, and 73 to that of Electrical Engineering.

Forty-three magazines are subscribed for, thirteen by the Mechanical Engineering, thirteen by the Mining Engineering, nine by the

Electrical Engineering, and seven by the Civil Engineering department. An assistant has been employed to care for the reading-room, and it is now open during certain hours of the day and evening.

The library of the Chemical Laboratory has increased to 352 volumes.

The total number of books now registered, including those belonging to the various departments, is 11,442, being an increase of 2,388 over the number accessioned before September, 1894.

The future of the library presents a serious problem. It has far outgrown its present accommodations and the cases provided will no longer contain the books. Every available space is occupied, and the floor is the only remaining resource. In the public document room, that also has been utilized to such an extent that to search there for knowledge is perilous, and to find it well nigh impossible. During the winter of 1895-6 the books of the literary societies of the college were transferred to the main library. Many of these are still stored in the document room.

The cataloguing of books must soon be suspended, unless some provision is made for shelving them.

Similar conditions obtain in the reading and pamphlet rooms.

The reading room is too small to seat comfortably those who use it, or to allow of a sufficient number of tables for the accommodation of the periodicals. The capacity of the pamphlet room is taxed to the utmost, and reference to its resources becomes daily more difficult. Stored in its recesses are long files of unbound magazines which would be of great value if bound and placed within the reach of readers. The necessities of the library cannot be too strongly emphasized or too promptly relieved, if its usefulness is to continue. The need of a building devoted especially to its use is very urgent.

Not only is the space allotted to it in the college building too limited, but it is occupying rooms which are coveted and will soon be required by other departments of the college. A strong objection to its present location is the noise occasioned by the necessary movement in the halls, a disturbance which is constant and annoying.

Since the importance of the library to the educational work of the college is unquestioned, and since no course of special study however complete can suitably equip for the contingencies of life a "bookless man," one who "has suffered his interest in the things which make up God's knowable universe to shrink until it reaches no farther than his eyes can see ,and his ears can hear," its needs demand speedy and substantial recognition.

In the autumn of 1896 the Western Pennsylvania Library Club was formed. Your librarian and assistant have enrolled themselves

as members, hoping thereby to bring the library into touch with other institutions of the same kind, and to share the impulse and inspiration now animating library organizations throughout the land. The efforts of the club are at present directed toward obtaining State legislation in the interest of the extension of library work.

The growth of the College library and its increasing responsibilities, have made the services of an assistant necessary, and at the beginning of the Fall session the position was assumed by Miss Anna MacDonald. It gives me great pleasure to acknowledge her faithful and efficient co-operation in all of the work undertaken in the library.

Respectfully submitted,

HELEN M. BRADLEY,
Librarian.

December 31, 1897.

X.—MATHEMATICS.

To the President:

Sir:—I have the honor to present the following report for the Department of Mathematics:

The year eighteen hundred and ninety-six just closing, no less than other years, leaves behind it certain problems solved as well as lessons yet to be learned. We are glad of this opportunity briefly to review our work and take counsel for the future.

The courses of study laid down in the catalogue remain unchanged, but several changes in the execution of them have brought out entirely new phases of our work. The special course in Pure Mathematics is now for the first time in full operation, with students in each of the classes. While certain minor changes have suggested themselves, the course as a whole starts with little friction and considerable promise.

Students with some mathematical taste seem to find in it more work than is given by colleges generally in Mathematics, as well as a generous and perhaps ample scientific course, from which the humanities are not absent: The senior year of this course has added six hours per week to our work of last year.

Second.—The Department has assumed general supervision of the mathematical work of the sub-Freshman year; some valuable results already appear. We are able to give better articulation to the Mathematics of all classes. This alone has added regularity and steadiness to sub-Freshman recitation and examination work. Moreover, a certain esprit de corps is surely growing up in the class which we are not slow to take advantage of.

Third.—Fifty hours of astronomical work is committed to us this year for the first time. This branch, so important to both scientific and general courses, we propose to teach as formerly from a descriptive and, so far as the class is prepared for it, from a mathematical point of view. We believe that we can make it one of the most valuable courses in college, and one which all students not pursuing strictly specialized courses might well be scheduled to take. There seems to be no reason why a college of our standing should have such a short and poorly patronized course in a subject of such general interest and import. The co-operation of the trustees has already been asked to secure the proper apparatus; not instruments for research, but instruments necessary for purposes of instruction.

Fifteen thousand dollars would be necessary to secure the equipment of a small working observatory. One thousand dollars would buy some of the more important models which are absolutely essential to expeditious class-room work.

A skeleton celestial globe, dynamical top, star map, and orrery of some kind should be purchased at once.

It is well understood that the present status of the College requires students in most courses to have a practical working grasp of the Calculus at the end of the Sophomore year. This fact has made plain at least three things. First: We ought to require Solid Geometry and perhaps more Algebra for admission to the Freshman class. We now cover College Algebra, Solid Geometry, Plane and Spherical Trigonometry, Analytic Geometry, (including some Solid Analytics), Differential and most of Integral Calculus in the Freshman and Sophomore years. Not only is the time at our disposal plainly too short in which to prove and illustrate so many theorems, but we also find that the average student grasps with difficulty fundamental conceptions so varied in two years. The growth and nourishment of minds demand, especially in mathematical work, a certain leisure for digestion, as well as time for practice. Second: All the accessories that the college can possibly afford should be put at the disposal of the instructor. A model which at a glance forms a concept in a student's mind, which otherwise must have required an hour of the instructor's time with the class, is economical from a financial point of view, even if used but once. The small collection which we now have in constant use ought to be considered, as it is, only a nucleus; and provision be made for a gradual but certain increase. Books also are as much a necessity to us as tools to the mechanic and chemicals to the chemist. Not all our teaching can be demonstrative. Certainly then, lectures would be unprofitable or wasteful of time, according as no demonstration or full demonstration is given. Our only alternatives are to give references to books, or to place in the hands of each student mimeographed sheets which, from the nature of the case, must be brief and perishable. A good assortment of mathematical books would add indefinitely to the resources of our department. Finally, the Board of Instruction should be made as efficient as possible. No single thing is so important to our work as this. In June Messrs. Wolfe and Sellew presented resignations which were accepted, and the services of Dr. Benedict and Dr. Taliaferro were secured to fill their places. We make no hesitation in saying that we are pleased with the work of these new men, as shown by the spirit of their classes and the result of the Fall examinations.

It is to be remembered, however, first, that Dr. Benedict does not give all his time to mathematical teaching; second, that Mr. Hender-

shot was employed to assist during the Fall session of last year, and that the tension this fall without such assistance was extreme; third, that the assistant in Astronomy whom the trustees authorized last year, has not been employed. In view also of the increase in hours due to large entering classes, special work in mathematics, new work in astronomy, and the new subject of computation introduced into the Agricultural course, it may fairly be said that our teaching force is smaller than last year. One other matter which I would be glad to have presented to the trustees has been in mind now for two or three years, viz: The organization of a Summer school of mathematics. It seems to us that it might serve the double purpose of furnishing assistance to those who find themselves unprepared for entrance to college at the June examinations, and second, provide courses which could be taken by High School teachers of the State and others, at a small expense: thus doing the public and ourselves a real service. A detailed account will be found in a supplementary report. Nothing but hearty co-operation and generous effort could have accomplished the work that we have undertaken this year. We owe no little to the consideration of other departments, and your own counsel and support. The firm resolve of the students to master daily the work assigned, the fidelity of instructors, the kindness of all and especially some heads of Departments, the assured sympathy and support of the Board of Trustees, have not only made possible whatever has been accomplished, but start us upon a year of greater expectations.

To the Trustees of the college through you, we here present an account of our needs and our stewardship, and to you, sir, our most sincere and hearty thanks.

Respectfully submitted,

J. M. WILLARD,
Professor of Mathematics.

State College, Penna., December 30th, 1896.

ENGINEERING BUILDING—FRONT ENTRANCE.

XI.—MECHANICAL ENGINEERING.

To the President:

Sir:—I have the honor to make the following report for the Department of Mechanical Engineering for the year 1896.

In the main the results attained throughout the past year have been gratifying, especially during the last session when unusual interest characterized the work of the students.

The course of study, has remained essentially the same as in 1894, when it was so fully reported upon, and though changes must continually occur in details of the work, the same underlying principles which have led to the adoption of the course prescribed, continue to pervade methods in general.

It has been a source of satisfaction to observe that notwithstanding the decided business depression our students have had no difficulty in finding positions. The Mechanical Engineer is, perhaps, more dependent upon manufacturing interests than any other member of the engineering professions. This does not mean, however, that the field for him is necessarily narrow; his work is widely comprehensive in its application. His training prepares him not only for designing, constructing and operating all kinds of appliances used in the manufacture of commercial products, but, at the same time, gives him a groundwork from which he may develop into the most successful manager and superintendent of large business enterprises. The fact should be recognized that probably no course of instruction is wider in its application, or prepares a man more completely for general usefulness than that of engineering. It is necessary only to examine the records of the graduates of the older and better technical schools of the country to be impressed with this fact. Among them are found presidents, vice-presidents, managers and directors, besides chief engineers in the larger and more successful business firms throughout the country.

In this course of study the relation between think and do is continually emphasized. The student is not taught away from the ordinary actions of life, but has impressed upon him the truth that the deepest thought may be involved in matters of every day occurrence. He learns that the design of the simplest structures may require a knowledge of difficult mathematical deductions; that he only who has thorough command of the Calculus can truly understand the idiosyncrasies of steam or other motors; in a word he comes

to know on the one hand the thought value in practice and on the other, the practical value of disciplined thought. This method of training presents the details to which the application of theory is made from new and unexpected points of view and creates an interest in these details otherwise impossible to attain. Thus interest is aroused not only in the acquisition of knowledge, but also, and perhaps to a greater degree, in its application. And herein lies a danger which is being realized by many of the technical institutions of the country. A wide spread preference for purely technical work, as evinced by students and parents, has led certain colleges to specialize to such a degree by the introduction into their curricula of laboratory and shop work and applied subjects, as to make necessary the exclusion, in large measure, of the humanities, an exclusion which must result in loss of standing to the engineering graduate. There are many causes that lead toward this specialization in technical courses, not least among which is the fact that young men are more likely, upon graduation from narrowly applied courses, immediately to secure remunerative positions. They therefore wish to see that their work will bring them dollars and cents at once, and unless they recognize the direct utility of a subject in their course, they feel that it should have no place there. The young men who are entering this institution at the present time need to have the fact especially impressed upon them that their college training can be, and, in fact, should be only a foundation upon which to build the super-structure, the broader and firmer the foundation, the more certain being the guarantee of future achievement. Many of them enter upon the work having had only the most narrow and meagre preparation, in quality and quantity barely sufficient to admit them. To such it is imperative that there should be offered something better than a severely technical course. Mechanical excellence alone must bring them a limited success. At first the engineering graduate is apt to be surpassed by the mechanic, the accountant, or the draftsman, but in the end his power in the application of thought to his effort will enable him to pass with rapid strides the man whose training has been in practice alone. As regards the relative amounts of time to be devoted to theory and application, observation leads to the conclusion that the exceptionally strong student receives the greater benefit from the theoretical side of the work. The making of applications comes to him without effort and his time consequently is as a rule more judiciously spent in the investigation of theory. On the other hand, many students derive little advantage from theory unless it is applied in the most detailed manner. It is therefore necessary in mapping out a course to find a mean that will best meet the needs of those of each condition.

It will be a fortunate circumstance in its bearing upon our work when the school system of Pennsylvania has been so re-organized that the requirements for admission to the engineering courses may be made higher. I make this statement knowing that this college is frequently criticized on the ground of the high grade of its requirements for admission. I am confident that when the facts become better known such criticism will be lodged where it justly belongs. Our able State Superintendent of Public Instruction is doing much to bring the truth of the matter into more general recognition. The people of Pennsylvania would not be satisfied if our graduates did not compare favorably with those of similar institutions, and criticism would be more severe, and in my judgment justly so, if our men lagged behind when placed side by side with other graduates. And yet, what are we asked to do, and in fact, doing, to a remarkably successful degree? Taking men with but a modicum of the usual preparation we undertake to give them a broad technical education. Nine-tenths of the institutions of the rank and character of ours require for admission to the engineering courses from one to two years of modern language, solid geometry, and, in many cases, trigonometry ;while we require none of these. This loss means a great deal more than simply an omission of preparation in the subjects enumerated; it means the need of a general training which would enable the student to do much better work in his college course, and also to accomplish much more. Comparison has been made with such colleges as the State Institutions of Ohio, Illinois, Minnesota, Wisconsin, Missouri, (certainly Pennsylvania should not rank behind these States,) and others of undisputed standing.

The success of our graduates testifies to what we are accomplishing. We assuredly have reason for gratification when measured by this standard, which, in fact, is the only fair standard for educational institutions. But we cannot be satisfied nor should the people of the State remain content until the Pennsylvania public schools are so systematized that there shall be no link omitted between their grade and that The Pennsylvania State College should attain. When this improvement of the school system has been accomplished our college will be on a plane where it will be comparable with the most advanced State Institutions in the Union.

Lack of preparation, though deplored by all, is probably felt more keenly in technical departments than in others. Their work is of a clearly defined character, and must to a large degree follow definite lines. If the preliminary training has not been good not only is the quality of the work as a whole detracted from, but an undue part of the special work must give way to those general subjects which are essential to the higher attainments of a professional career. I do

not wish to be understood to imply that such work (except that of the preparatory grade) should ever be entirely excluded from the course. On the contrary it is my belief that the retention of a certain amount of it cannot be too strongly advocated, and it is interesting to note that many colleges that have had these subjects eliminated from their curricula are gradually re-inserting them. The question of the relative amount of time that shall be assigned to culture and general information on the one hand, and to shop, laboratory and the detailed application of principles on the other is difficult of solution.

In a comparison of our schedule of work with those of thirty-seven of the better grade institutions that give technical courses, it is found that in the Mechanical Engineering course we offer to our men very near an average amount of work in the Languages, English and Mathematics, while in History and Political Science we give about four times the average. With classes of young men more evenly and fully prepared on entrance, these amounts might be decreased to advantage.

As to material equipment it is appreciated that we have made rapid progress and take good rank with sister institutions. Yet even here a number of them are much in advance of us. The cost of equipment alone, exclusive of buildings, of the Electrical and Mechanical Engineering Department of Cornell University has amounted to over $200,000, and of the Civil Engineering Department to about $60,000. President Mendenhall of the Worcester Polytechnic Institute, estimates that the building and equipment of their Mechanical and Engineering Department alone cost them not less than $250,000, $100,000 of which is in equipment. The Electrical equipment which is in another building cost not less than $20,000. At the University of Wisconsin the shops alone cost $75,000. At Purdue University in Indiana, the equipment of the Mechanical and Civil Departments cost $95,000 and of the Electrical, $20,000. At the University of Michigan the equipment of the Mechanical and Electrical Departments cost $70,000. It is to be noted that these figures are for equipment alone, not including buildings, except in the case of the Worcester Polytechnic Institute, and there the equipment cost $100,000 for the Mechanical Engineering Department. Our Engineering building is adequate for two Engineering Departments as originally designed and no expenditure in this direction will be needed for these departments until the growth in numbers of students makes it necessary to extend the shops and laboratories. Further equipment, however, is indispensible to meet the present demands of growth, and to enable us to advance with the times. During the past two years no appropriation for equipment has been made to this department, and the needs in this direction are consequently urgent. As an illustration of the necessity for continuing to add to

our experimental and illustrative material, permit me to call your attention especially to the immediate need of appliances for work in compressed air. The introduction of compressed air where steam was formerly used and its present competition with electricity as shown in the street railway service of New York, and other cities, are signal indications of its growing importance. Experimentation in its adaptation and economic use is being made throughout the educational and practical worlds, and the young men of our college should find means here for carrying on and gaining familiarity with such timely investigations. They will otherwise probably find them elsewhere.

List of Appliances Needed for the Mechanical Engineering Department.

Air compressor, piping, valves, etc.,	$800 00
Air brake appliances,	250 00
A plain side valve engine for practice in valve setting,	600 00
A mercury column,	500 00
An Alden brake, or absorption dynamometer,	300 00
An Emerson transmitting dynamometer,	300 00
A Weber dynamometer,	600 00
Several Proney brakes,	350 00
Pressure gauges, manometers, pyrometers, etc.,	300 00
Draft gauges and combustion apparatus,	250 00
Calorimeters,	285 00
Steam engine indicators,	140 00
Fuel calorimeters,	324 00
Indicator attaching apparatus,	45 00
Two tachometers,	140 00
A Moscrop speed recorder,	175 00
Injectors, inspirators, etc.,	185 00
Gauges (ordinary), thermometers, etc.,	375 00
A 60,000 testing machine,	900 00
A 100,000-pound testing machine,	1,000 00
A 200,000-pound testing machine,	1,450 00
Thurston's autographic testing machine,	550 00
Two planimeters,	60 00
A belt dynamometer,	175 00
A VanWinkle powermeter,	430 00
Hydraulic motors, (turbine, &c.,)	925 00
Boiler test pump,	30 00
Six water meters,	200 00
Stand pipe for hyraulic work,	375 00
Wiers, tanks, &c.,	275 00

A lubricant testing apparatus	375 00
Locomotive model	475 00
Drawing appliances	135 00
A mortiser for carpenter shop	50 00
Small power hammer for forge room	325 00
Three engine lathes	725 00
Small tools, gauges, callipers, etc	550 00
Grinding machine	680 00
Total	$15,904 00

The Hydraulic Laboratory equipment has not yet been provided. The need here is great. It is to be hoped that it may be found possible to provide for it at an early day. The basement of the Engineering building has never been painted, except that part now occupied by the Electrical Engineering Department. This painting should be completed at once, in order to afford both protection and finish. Estimated cost $240.00.

Window shades have not yet been provided for the Engineering building. They are much needed. An estimate of the cost ($310.00) was presented sometime ago. Ground glass for the doors is also needed. The cost would be about $100.00.

Engineering Building.

Painting basement	$240 00
Window shades	310 00
Ground glass for doors	100 00
Total	$650 00

Steam Plant.

A considerable amount of permanent improvement has been made upon the steam plant during the past year.

The small tunnel leading from the main tunnel to the main College building has been uncovered and cemented and is now water tight and free from the leaks that formerly caused so much annoyance.

The cement floor in the boiler room, which was never satisfactory and which became so bad that it was necessary to take it out, was replaced by our own labor at a much smaller outlay than that for the original floor. The new floor promises to give good service.

A large quantity of old hair felt covering on the steam mains which was burned and rotten has been removed and re-placed by a first

class mineral wool covering. This covering is practically indestructible, and should not need to be replaced for many years. Gradually all the hair felt covering as it becomes deteriorated is being taken off and replaced by coverings better adapted to our conditions There is still a considerable amount to be removed and several hundred dollars should be devoted to this purpose annually for a time.

Under the direction of this department four houses on the campus have been provided with steam heating apparatus during the last summer. These houses had previously been heated by hot air, a method which proved quite inadequate. Although we have not at the time of this writing had a sufficient amount of continuously cold weather thoroughly to test the efficiency of the present system, it is believed there will be no difficulty whatever in keeping the houses entirely comfortable in the most severe weather. The work of the contractor, Mr. Allison, has given eminent satisfaction.

Since soft water has been used in the boilers repairs on them have been insignificant.

I desire again respectfully to call your attention to the need of providing additional storage room for coal.

The capacity for storage could be doubled by introducing coal and ash conveyors and placing bins in the boiler house immediately above the boilers. If this were done the helpers in the boiler-house could be dispensed with, as it would be possible with these appliances for one man to do the work more easily than it can be done by two at present. Furthermore the cost of getting the coal into the coal house would be reduced at least one-half. The expenses for maintenance in connection with our heat plant would thus be reduced at least $450 annually. This sum is five per cent. on $9,000.00. For about $8,500, the improvements could be made. With the present limited capacity if strikes were to occur at the mines or on the railroads we might be placed i nserious straits.

Two boiler feed pumps should be secured at an early date. Those now in use were put in when the boiler house was built. Besides their deterioration from wear they are entirely too small for the present service. It is necessary to run them so fast in order to supply the required amount of water for the boilers as to make it impossible to keep them in proper repair.

The piping in the basement of the main College building should be overhauled. This can be done with the regular force of men during the summer months. Several hundred feet of large pipe will be needed. Estimated cost, $300.00.

Summary of Needs for Steam Plant.

For storage of coal and conveyors,	$8,500 00
For feed pumps,	450 00
Pipe for basement main building,	300 00
For covering for pipe in tunnel,	400 00
Total,	$9,650 00

Respectfully submitted,

LOUIS E. REBER,

Professor of Mechanics and Mechanical Engineering.

January 1st, 1897.

ENGINEERING BUILDING—FRONT ENTRANCE.

XII.—MILITARY DEPARTMENT.

To the President:

Sir:- I have the honor to transmit the following report upon the military department of The Pennsylvania State College, with which I have been connected from the beginning of the Fall session of this year.

Instruction, in the main, has been practical, but has also partaken of the theoretical, the latter having been confined, of necessity, to the officers of different grades.

Practical instruction has been in the School of the Soldier, the School of the Company, and, to a limited extent, in the School of the Battalion, in Infantry Drill Regulations, United States Army.

Theoretical instruction has embraced Definitions, General Principles, and short recitations upon the subjects enumerated under the head of practical instruction.

Theoretical instruction also included memoranda, having for their object the right understanding and exercise of military authority; tending to remove the prevalent distaste, among associates, with respect to giving and receiving orders, and looking also to the habitual erect carriage of the body.

Regarding the latter point, it is interesting to observe that when a cadet puts on his uniform, he is apt to straighten himself at once, improving, for the time being, the habit engendered by the comparatively negligee civilian dress. Attention may be pertinently called to this, as those things have predominant influence, to which a man is habituated the major part of his time. One enlistment, five years, in the United States Army, used to be considered well spent, if the subjects hereinbefore mentioned became well understood in that time. Now that the enlistment is for but three years, many doubt if that time is sufficient, particularly in the cavalry and artillery, for the soldier's training. In the time at our disposal, therefore, it was not thought well to attempt more extended instruction.

The previously indicated subjects which have been engaging attention during the term just closing, embrace all the principles, upon the continued repetition of which, until thoroughly mastered, so much depends, in the development of the physical well-being, and the forming of habits of obedience and command, of promptness and precision.

Words of commendation are due that portion of the collegiate body living in the main college building, whose rooms are subject to inspection by the commandant.

Good order and tidiness prevail, with rare exception, and the regulations imposed are cheerfully complied with.

I should feel derelict not to ask for an appropriation of not less than one hundred dollars, to be spent in equal parts, (1) for the equipment of a drum corps, and (2) for the purchase of a few more officers' swords.

The sword is a badge of authority and an almost indispensable aid to its exercise.

The drum promotes the morale and the orderly movement of organized bodies of men.

The abundant return for such expenditure is guaranteed by the past history of state and nation.

A company of soldiers, with four exceptions, once (in 1877) surrendered their arms to a mob. The four exceptions were four students of The Pennsylvania State College.

I will close this report with a statement from the thesis of a member of the present Senior class, recently handed to me, setting forth pertinently present and future good.

"According to my views, I think military drill very beneficial to students. It gives them a great deal of needed exercise which some would not otherwise get. It also gives them a more manly bearing which is noticed in every person who has advanced to any considerable extent in military regulations. The national benefit derived from this department should not be overlooked. It makes more loyal citizens, and, in case of war, it is of utmost importance."

Better reasoning could not be given by veteran publicist or logician.

Very respectfully,

D. C. PEARSON,

Capt. 2d. U. S. Cav., Commandant

State College, Pa., Dec. 31, 1896.

XIII—MINING ENGINEERING.

To the President:

Sir:—There is little in the regular college work that calls for special mention from this department. The schedule of exercises, as announced in the catalogue and summarized in previous reports, has been carried out, and, though circumstances have arisen to prevent the attendance of two members of the teaching force during a portion of the session just closed, but two exercises were omitted. In the former report was revealed, in tabular form, the number of exercises to which students in the course in mining engineering were due and also the amount of time devoted to the several branches of the profession, an inspection of which shows the equipoise of the mechanical, chemical and cultural branches which is well-suited to the needs of the Bachelor of Science in Mining Engineering. It is earnestly hoped that, in the near future, the standard of admission may be further raised and that it will be possible to produce engineers within the ordinary four or five years of a university course.

The only modification made during the year has been one in the plan of study which aims to familiarize the Senior with commercial practice. A liberal use is made of manufacturers' catalogues, price lists and trade periodicals and this should give the student a broader development and training for future achievements. More failures are recorded for lack of this kind of training than of engineering skill. Trying though this method may be, ofttimes discouraging, too, to the student, it is productive of the most gratifying results. The graduates from this course are very fortunate in their several chosen fields, the first three occupying particularly prominent positions of responsibility. Of those who followed partial mining courses but one has not entered into the practice of his profession. The present attendance upon the course is not commensurate with the opportunities for employment, for, of the entire administrative staff of the mineral industries of the United States, exclusive of clerical officials, nearly one-fifth, or 2,610, are employed in this State. In preparation for these positions the total attendance upon the mining courses in the several institutions of learning in this State, so far as can be learned from catalogues, does not reach eighty, of which we have nearly one-third.

The department still enjoys the privilege of contributing to the instruction of students in courses other than mining and I am more

than pleased with the thoroughness of the work there performed by the teaching force. It is with pleasure I acknowledge the appointment this year to our force of Dr. F. J. Pond, whose work abroad has been so highly commended and the retention of Mr. T. C. Hopkins on our staff as Assistant Professor of Geology.

The department maintains the following industrial relations:

1. Assays for citizens of the State at the mere cost of materials consumed.
2. Inspection trips and expert opinions.
3. Investigations of an economic nature.
4. A system of free lectures in mining centres.
5. The Mining Bulletin, a free bi-monthly journal.

The number and variety of problems submitted for opinion or analysis has reached eighty-three and these samples from various sources embrace many purposes, public and private, from fossil-food to electric waters and from brick making clays to diamond bearing sandstones. Forty-seven of these were analyses or assays of native rocks for copper, gold and silver, the charges for the same having been exceedingly light. Six prospecting trips were made to give expert assistance in the solution of some industrial or scientific problem. Other requests were refused either because they partook of the nature of private enterprise not of a general public benefit or because, from the data presented, the investigation did not promise any important results. The most extensive investigation, thus far ready for publication by the teaching corps, is that of Assistant Professor T. C. Hopkins who, in an appendix to this report, presents the results of the field and laboratory examination of the red sandstone areas of Pennsylvania.

The current year records the installation of courses of free lectures in mining communities for those desiring experimental aid in their home studies. Successful in other countries, the experiment was made here, but some time elapsed before the tender made through the pages of the Mining Bulletin—our sole medium of advertising—was accepted. Since that time eighteen lectures have been delivered in eight mining centers. The topics for the lectures were carefully selected and the treatment of the subjects was made as entertaining as possible with the liberal use of lantern and apparatus. The audiences were large and appreciative. The interest manifested by the audience was encouraging and the reception given to the members of our corps was flattering. I most earnestly plead for the maintenance of this useful branch of our work which aids in the dissemination of valuable technical information among mine employes. The college would fail in its duty as a public educator did it neglect this field of work. The average cost of each lecture, for supplies consumed, transportation and traveling expenses, is $4.87, an

amount so trifling, compared with the results, that it is hoped provision will be made not only for the system on its present basis but for an extensive traveling equipment with which to respond to the present demand. The department is under many obligations to other schools for the loan of apparatus. It may perhaps be stated that these lectures have been conducted without encroachment upon the time or any interruption of College studies, for, with one exception, they have hitherto been scheduled for vacation periods.

The greatest single line of expenditure ($708.09) for the year has been in the erection upon the campus of a column thirty-two and seven-tenths feet in height, composed of two hundred and eighty-one representative building stones of the State gathered from one hundred and thirty-nine different localities. It exhibits many of the varieties of structural material with which Pennsylvania is endowed and reveals to the architect at a glance the possibilities of artistic combinations from our native products. To the builder, similar information is given together with that afforded by the reports of the physical tests and microscopic examination of its constituent specimens. Yet another feature was developed and carried out in this column. The geologic age of each quarry contribution was identified as nearly as possible and special efforts were made to secure characteristic specimens from each geologic formation that occurred within the borders of the State. The labor and expense involved in these missions by the special agents was well returned in the location of new quarry sites and the ultimate securing of representative material. This done, the Polylith was erected in courses, each course being composed of stones of the same geologic age whatever may have been their geographic home and each being laid in its relative geologic position and of a thickness somewhat commensurate with the average aggregate thickness of the formations from which the stones came. Thus the column is not only picturesque but exceedingly valuable to student, visitor and artisan.

The Mining Bulletin continues to receive cordial acknowledgment and I trust that means may be provided for its maintenance. I believe that its discontinuance would be felt by our mining communities for numerous solicitations have been received by us for copies whose issuance had been delayed beyond the usual time of mailing. Six issues of three thousand copies each have been distributed and, as our reserve supply has been closely drawn upon in our recent numbers, it will be necessary during the coming year to print thirty-five hundred copies. I may state here that, as the Mining Bulletin has just been put upon the list of second class mail matter, the future saving in postage may be expended in an enlargement of our editions, provided the present agitation in Congress against unprofitable mail matter may not displace it. The total

cost of the distribution for the present volume of 140 pages of six numbers has been $650.59, of which the sum of $148.64 has been paid for postage. Of the total issue, nearly ninety-four per cent. is circulated in this State.

The additions to our equipment during the past year include models of blast furnaces, a coke oven and a mine. A Wolf lamp has been added to our working museum and various contributions from manufacturers have been appropriately installed. Collections of domestic and foreign iron ores are being prepared for the department.

For accessions to the library there has been expended the sum of $50.15, exclusive of periodicals and donations from various sources.

Among the needs of the department we may enumerate, without further elaboration, the following:

For Class Room—Lantern slides to illustrate geologic, mining and metallurgic progress.

For Museum—Additional models of coke ovens, furnaces and machinery; a collection of microscopic sections of rocks; additions to the lithologic collections.

For Laboratory—Facilities for giving instruction in the roasting of ores, in the coking fuels, in testing refractory materials, and in extraction of gold from its ores and its separation from silver; appliances for the examination of furnaces and for testing fuels.

For Field Work—A photographic outfit.

For the Lecture System—A portable lantern, lecture apparatus and additional lantern slides.

For the Mining Bulletin—Support for bi-monthly issue of thirty-five hundred copies each.

The urgent need of this department is room. The entire equipment of the department should be readily available to the student and to the visitor and models and working appliances should have ample space for exhibition and operation. The present work of the corps is seriously hampered for lack of room and enlargements in its scope are not possible without further encroachments on other departments. This affects not merely the educational work but its industrial lines as well. That it may serve its end in the development of the mineral resources and mining industries of our Commonwealth, it should be housed in a building perhaps with its museum grouped with those of allied sciences, as for example, Biology, Botany, Zoology.

Thanking you for many kindnesses extended to the department, I am,

Yours very respectfully,

MAGNUS C. IHLSENG,

Professor of Mining Engineer and Geology.

State College, Pa., Jan. 1, 1897.

XIV.—MODERN LANGUAGES.

To the President:

Sir:—The prompt attention which you gave to the needs of this department a year ago has very materially aided us in expediting our class exercises and in accomplishing far better results. Out of a class of 66 Frshmen that took the Fall term examination in German a year ago, 27 were conditioned; out of the class of 63 this year, only 7 were conditioned. The work and the examinations were as nearly alike for both years as they could be made, but the present Freshmen had been better prepared in English upon entering, had the advantage of vastly increased black-board surface for drill, and suffered no delay whatever in getting their books when needed.

The interest aroused early last year in sight reading was such as to warrant a request of the faculty to offer the Freshmen in both German and French an extra recitation a week during the spring term for the purpose of reading some simple and interesting literature requiring no special preparation. This request was courteously granted. Attendance was entirely voluntary. The membership of the German section was 43 and the average attendance was 25. From this it is seen that 58 per cent. of the class were sufficiently interested in this voluntary exercise to get from it what pleasure and profit they could. The results in the French section were about the same. Moreover, at the close of the Spring term, a course of German reading for the summer vacation was laid out and recommended to this same class with the result that 18 per cent. read from 30 to 100 pages of the works assigned, while 28 per cent. read less, or reviewed the grammar.

In view of this interest in voluntary reading, it would be gratifying to the department and especially to a large number of students, if they could be permitted to take out and use from Saturday noon to Monday morning such books of the department library as should be recommended to them from time to time. We feel confident that much of the said period, usually spent idly or questionably, would thus be turned to good account.

In this connection permit us to call your attention to a liberal donation, by two leading publishing houses and one individual, of 96 volumes of first and second year French, German and Spanish texts, secured for the purpose of arousing a wholesome interest in these

languages and of encouraging independent reading. Ten other volumes were purchased for advanced work.

The details of work in the various modern language courses were so thoroughly described in last year's report that it is not deemed necessary to reiterate them here.

There is, however, one phase of our work which deserves special attention. Almost exclusively from those who are unfamiliar with the possibilities and limitations of modern language work in colleges, is often heard the query: "Why are not students taught to speak French and German? Is not this the object of their two or three years' course." To the latter question we make emphatic answer: "No, not primarily." As stated in last year's report, to claim for the large majority of our students anything more than a ready and thorough comprehension of a foreign language, when read or spoken, as the result of about two hundred recitations would be preposterous as well as dishonest. Only one way is open for the acquisition of French or German as a living instrument of thought and expression, and that is to associate for six months or a year with none but educated Germans or Frenchmen. To be able to read intelligently the literature of average grade of difficulty, in the time mentioned, to understand the language when spoken or read, to converse on only ordinary topics and to write simple letters is as much as can be accomplished in the time allotted for about ninety per centum of the students.

The so-called natural method, the object of which is to enable the student to speak and think in the foreign tongue, takes very much more time than can ever be available in our collegiate institutions, even when the vernacular is never heard. Investigation and observation show that a young educated German requires from one to two years of residence among English speaking people to acquire a correct and fluent use of the new language and that it takes an American graduate from six months to a year of residence in Germany to acquire a speaking knowledge of German. Since this is true when all the working hours are given to a strange tongue, what can an undergraduate in the electrical course, for example, be expected to accomplish in only one hour a day for seven months—the actual time given; or even, as its equivalent, in five hours a day for only two months, as in a German school; or in ten hours of constant association, for twenty days, as in business or in the family circle? Can a class of twenty-five students and one instructor do better within the same limits of time? Nothing short of four times the allotted time could bring about the mastery of the language for conversation but not for general reading and culture at the same time. Even in this case nothing more than common ideas could be expressed, the vocabulary would be small and the educational value insignificant.

By such a method there would be no mental stimulus, no powers of discrimination, no careful analysis, no positive intellectual gain and no increased mastery of the vernacular. The process, is at best, only an imitative one, and that too in the period of the student's life when the dominant educational processes are no longer imitative, but discriminative and constructive. While in the face of these facts gathered from experience and investigation it is not deemed the wisest expenditure of the apportioned time to employ this subjective method exclusively, it is of the utmost importance to give to one phase of it, namely, extensive sight reading, at least a fourth of our time; not for the purpose of enabling the student to think and talk in German and French, though this is often accomplished incidentally, but for the purpose of acquiring the power of apprehending the meaning of the language, of appreciating its thought and of feeling its force.

Aside from this subjective way of acquiring an understanding of the language, there is, in the opinion of the department, a most rational justification in the objective or scientific method that serves to stimulate mental operations, to contribute powerfully to the mastery of the vernacular, to cultivate the power of expression and to discipline the mind for keener intellectual analysis and discrimination.

The process of becoming familiar with a well stocked vocabulary and with the whole meaning of individual words, so that they are no longer objective but subjective, and their meaning flashes instantaneously upon the mind, is one of slow growth. It takes time and long practice to feel the full force of the voice, mood, tense, the inflectional changes in the person and number of the verb, and the declensional endings of nouns, adjectives and pronouns; and to have a keen appreciation for the idioms and a strange word-order. The process must of necessity at first be conscious, objective.

And yet, notwithstanding these many elements and possible combinations that must be kept in suspense, so great and many that no mind could begin to carry them even in one year's work, which at best means only one hundred and twenty-five hours of practice in the class-room, a gradual acquisition of the subjective apprehension of the foreign language is inevitable. At the end of five terms the faithful student understands nearly all that he hears or reads and expresses himself fairly well both in speech and in writing, so that an additional residence of only a few months in France or Germany, as the case may be, is all that is necessary to make him master of the spoken as well as of the written language. The greater part of his work, however, during these five terms is objective, and only those who continue through the third year can hope to pass entirely into the subjective realm, where the process of translation no longer is necessary for the appreciation of the

language. What Professor Benedict, of Cornell, says of the classical languages is equally true of the modern languages; it is with learning to read a foreign tongue as it is with learning to play a musical instrument. "The technique of the art," he says, "can not be neglected, and he who is the most perfect master of the technique will be the surest of making a player in the end—at least he will never make a player without it." So in learning to understand French or German "the process is not one of divination," as in the case of the natural or subjective method, "but of sober inference from positive knowledge of the meaning of words, the force of inflections, word-order and the subtleties of syntax; and no one who is not master of these can any more translate," or even read intelligently, "at sight than he can read music at sight without having previously mastered the technique of the particular instrument on which he wishes to perform."

It is earnestly hoped that the efficient services of Mr. I. L. Foster, instructor in modern languages, may be retained for at least another year. Much of our success is due to his unselfish efforts and excellent qalifications. Any change in the teaching force at this time, it is feared, would very materially hinder the progress and disturb the quality of our work.

I desire, in conclusion, to express my gratitude for your helpful suggestions, hearty co-operation and keen appreciation of the pressing needs of the department.

Most respectfully submitted.

CARL D. FEHR,
Assistant Professor in Charge.

State College, Pa., Dec. 31, 1896.

XV.—PHYSICS.

To the President:

Sir:—The work of the Department of Physics during the past year has embraced the following eight lines, or groups:

(1) Elementary Dynamics and Vibratory Motion, in the Sophomore year. These two subjects, the former now taught in the School of Engineering, are fundamental to all the succeeding work in Physics, and are taken by all the students in the various engineering courses and the courses in mathematics and physics. All other students have a briefer course in them in the Fall session of the Junior year. (See 7.)

(2) A course covering the elements of Sound, Heat, Electricity and Magnetism. This course is also taken by all engineering students and those in mathematics and physics.

(3) A more advanced course in the theory of Heat, theory of Electricity, and theory of Light and Physical Astronomy. No student in any engineering course takes any part of this work. Those in mathematics take most of it; those in physics, all.

(4) A laboratory course in Physical Measurements. This includes the use of instruments of precision in the measurement of the fundamental quantities, space, time and mass, in measurements of other dynamical quantities, and in sound, heat, electricity and light. Parts of this are taken by students in the various engineering courses. It is taken completely only by those in the mathematics and physics courses.

(5) A laboratory course in Electrical Measurements. This includes the use of various instruments and methods of measurement of the important magnetic and electric quantities. It is taken by those in the Electrical Engineering course, and, more fully, by those in mathematics and in physics.

(6) A laboratory course of more advanced work in Physical (including electrical) Measurements; and including, if may be, some original research. This is especially for students in the mathematics and in the physics courses.

(7) A course extending through the Junior year of the courses in Agriculture, Biology, Chemistry, General Science, and Latin Sciences, and covering systematically, though briefly, the subjects usually designated under the term Physics, mechanics, sound, heat, light, electricity and magnetism.

(8) An elementary laboratory course, pursued as much as may be in relation with course (7), and embracing measurements in the various subjects of that course.

STATISTICAL SUMMARY OF STUDENTS.

Session.	Class Room.	Laboratory.
Winter,	37	34
Spring [39×2+9],	87	12
Fall,	52	19
Average,	59	22

The work of the department is arranged with reference to a threefold purpose, or function: (1) to provide a good outline of principles, and appropriate laboratory work, for students in the General Science Course and other Courses in which Physics, however important, is not a principal subject; (2) to provide a more complete course, stronger especially in mechanics, electricity, and heat, for the students of the Engineering Courses; and (3) to provide a full and advanced course for those who wish to make physical and mathematical studies the principal subject, with Mental and Civic Science, or Chemistry, or Applied Electricity, as prominent second.

Of the apparatus added during the year, the most important are a balance superior to any heretofore in this department, a Kelvin absolute electrometer, an electromagnet and accessories for fine work, an optical bench and accessories, and a complete X-ray outfit.

The X-ray apparatus was received but recently and has not yet been much used. But earlier in the year, using an old Crookes' tube and an old, almost unusable coil, some work was done, including two slight researches, one on the absorption (as heat) of the energy of the X-rays by mercury and by lampblack and the other on the effect of the X-rays on the thermopile.

Mercury, lampblack, and the thermopile are intimately connected with the measurement of radiant energy. All attempts to measure the solar constant have assumed that the energy of solar radiation is either in the form of heat or in some form totally convertible into heat by the apparatus used. For several years (see "The Electrical Engineer," November, 1892, p. 443) I have believed that this assumption needs better evidence before results in any wise dependent on it can be accepted as certainly correct.

On March 10, 1896, I exposed to the X-rays from a Crookes' tube actuated by a large inductorium, a paper box filled with pressed lampblack powder about 3 mm. in thickness, a paper box lid (empty), a paper box containing about 3 mm. depth of mercury, a piece of windowglass, a piece of thick sheet aluminum, and a silver quarter of a dollar, on the outside of an ordinary camera plateholder, containing a Carbutt dry plate. All colored paper was carefully removed from the top and bottom of the paper boxes and lids.

The mercury (as in an earlier trial) proved very opaque. The lampblack was highly transparent, apparently absorbing none of the X-rays. On March 16, I placed a paper box filled to a depth of 3 or 4 mm. with lampblack on the face of a thermopile of 19 pairs of bismuth and antimony, and over the lampblack the Crookes' tube. The thermopile could be quickly put in circuit, without moving it or the lampblack box, with a highly sensitive mirror galvanometer at some distance. The hand held for a second or two before, but not touching, the thermopile gave a deflection of 25 or 30 mm. The lampblack cut off any heat radiated from the warmed part of the Crookes' tube, but transmitted the X-rays, as shown in the experiment of March 10.

The coil was put in action, taking 1,500 to 2,000 discharges during about three minutes. Then the thermopile was quickly connected in circuit with the galvanometer. There was no certainly readable deflection. This was repeated four or five times, at intervals, with the same result.

It seems evident that the coating of lampblack used on instruments in studying and measuring radiant energy will not absorb (and measure) the total radiation, if there be X-rays therein.

It also seems evident that a thermopile (bolometer, etc.) will not truly measure radiant energy, if there be X-rays therein.

—El. Eng., Mar. 25, 1896.

(Subsequent researches have shown that in the solar radiation there are no X-rays.)

A little work has also been done during the year on a research on solar radiation, with a view to its direct use as electric power, without degradation into heat. Ten or twelve years ago, I was working for direct experimental proof of Maxwell's prediction that light is electromagnetic energy. The work of Hertz and others has demonstrated that electromagnetic radiations are identical in properties with light. But the practical problem of direct utilization without transformation, of the flood of electromagnetic energy falling upon the earth, remains unsolved; and material progress and civilization yet rest on the entombed coal miner.

In the early part of the year, I had the notes on Vibratory Motion printed. This subject, which was either not mentioned, or but briefly, in textbooks of Physics when these notes were first prepared some years ago, has been recognized as worthy of (proportionately) quite full treatment in all recent college textbooks of Physics.

The character of the subject and its treatment being such that it was necessary to take the notes very nearly verbatim, the printing of the text saves much time and labor of the class.

In each of the several lines of work named above, we meet the

need of additional apparatus and facilities, notwithstanding the increase of equipment from the last appropriation.

While a list of each particular piece or thing needed and its price would be tedious, I give the approximate aggregate cost of the things most needed in each of the lines of work:

1. Dynamics and Vibratory Motion,	$250 to $300
2. Elements of sound, heat, electricity and magnetism,	400 to 500
3. Theory of heat, of light, of electricity,	500 to 600
4. Physical measurements,	500 to 600
5. Electrical measurements,	700 to 800
6. Advanced physical work,	600 to 800
7 and 8. Class-room and laboratory work of non-engineering students, principally provided for in 1, 2 and 4,	200 to 300
To which should be added:	
Accessory apparatus for stereopticon,	300 to 400
General and miscellaneous items,	200 to 300
	$3,650 $4,500

An appropriation for the next two years like that of two years ago would complete a moderate equipment for the work now being done in this department of the college; with the present number and usual distribution of students. And by addition of instructors and good arrangement of daily schedules, a considerable increase in number of students would not call for very great increase of this equipment.

Of course, whenever it shall be determined to fully equip the Department of Physics with buildings, fixtures, apparatus, instructors, mechanician, etc., a much greater outlay for apparatus alone will be required. I have spoken of only the present or immediately prospective condition.

Respectfully submitted,

I. THORNTON OSMOND,
Professor of Physics.

State College, Pa., Dec. 26, 1896.

XVI.—PSYCHOLOGY AND ETHICS.

To the President:

Sir:—Reporting upon the work of the past year leads me to the following conclusions and recommendations which are most respectfully submitted.

I continue to note, what I am pleased to interpret as a growing interest in psychological and ethical subjects. That, too, not only in our immediate surroundings, but in the larger movements that are remolding man's social, and especially his educational, progress. The fundamental character of psychology to all systems of education is being more and more acknowledged. Among such evidences might be cited: the reports of the "Committee of Ten;" the "Committee of Fifteen;" the present renaissance of Child-study; and the movements within the National Educational Association. At last, it may be affirmed, applied psychology is entering upon its heritage of diagnosing and prescribing for our educational ailments.

In two directions, the work of the past year calls for comment. First, the partial fitting out of a laboratory has added to the interest and effectiveness of the psychological branches. It is now quite generally recognized as true, that psychology can no more be successfully pursued without a certain material equipment, than physics, chemistry, or biology. A specific appropriation has enabled us to make a very fair beginning in laboratory supplies. Our greatest difficulty, however, has been in keeping our needs within the amount subject to expenditure. It is not necessary to enumerate at this time or in detail the materials and apparatus now in possession of the department or contracted for future delivery. I refer below to the additional equipment necessary to supplement and render truly valuable our present one.

The literary needs of the department have not been overlooked, and the addition of one hundred and forty carefully selected books has already had a beneficial effect upon the student's class room and practicum work. Particularly, too, have the best of the current periodicals in these subjects given interest to the work. The science of psychology is growing to-day, not in books, but in periodicals—detailing the various fields of analysis and experiment—and, while there is a good deal of digesting, contracting and interpreting of materials demanded of the teacher, yet the pupil's conception is much enlivened and made effective by direct contact with the tentative and formula

tory side of a real science. The abuses of a text-book are thus eliminated, and dogmatism which youth of certain stages crave is supplanted by an active search of and thirst for truth. Here is also the opportunity for the individual element in all instruction. One student may pursue a topic much farther than others care to or indeed can be prevailed upon to do, and his presenting his results in the class room cannot but stimulate others. There is, too, a sphere in the education of every individual where the art of "letting alone" is of much importance than interference. I venture to hope that the number of psychological periodicals and laboratory "studies" may be increased rather than diminished, and that the early binding of the same may make them compact and convenient for frequent reference.

As to our needs in laboratory equipment for the next two years, I respectfully submit the following. Every item is absolutely essential; and the list has reached its present form only after repeated revisions of what would be highly desirable for proper instruction in psychological and educational lines. I also incorporate a small sum for books, periodicals, etc., in order that some of the most urgent gaps in our library may be filled and that a complete file of one or more psychological journals may be obtained. I would accordingly ask that the sum of $1,000 be available during the next two years, distributed to our needs about as follows:

Chronograph, paper, shelac bath and drying frame, ...	$165 00
Electric forks, time markers, batteries, tambours, keys, etc., ...	140 00
Models of brain, etc., Anzoux, Casciani, Aeby, ...	200 00
Dissection and drawing materials, chemicals, ...	20 00
Mounting shutter for rapid exposure, ...	20 00
Constructing apparatus for special psychological work,	200 00
Mounting and copying charts of nervous system, ...	60 00
Books, periodicals, binding, etc., ...	200 00

This and our present laboratory supplies, together with a comparatively small appropriation in succeeding years for growing needs, would enable us to meet reasonably well the urgencies of modern psychological instruction.

The second point of interest is that of the organization of a course of study. The present outline is very unsatisfactory for various reasons. First, it was made up with reference to other catalogued subjects, and there was of necessity some departure from the logical order. Second, considerable difficulty has been encountered, in individual cases, in adapting electives, both as to time and consistency, with the course as partially outlined. Third, experience has established the fact that the essential material cannot be con

fined to two years, at least it ought not to be so confined. Preparatory subjects, such as a study of the nervous system with practicums in dissecting and drawing its parts, and a study of the organs of sense, should begin in the Sophomore year, thus giving more time in the last two years to the more difficult subjects of psychology, ethics and philosophy. With a view to obviating these and other objections as well as giving to the student a stable relation from the beginning of his course, I submit herewith a schedule covering the four years.

Permit me to point out a few particulars with respect to it. The Freshman year is precisely like that of the General and Latin Scientific Courses. The Sophomore year introduces physiological psychology, with practicums in the nervous system, instead of Calculus (mathematics continuing until the spring session with analytics), otherwise conforming to general lines of culture as outlined in the general courses. In the Junior and Senior years, the work in the fields of psychology and philosophy assumes the lead; while, as in all courses, certain established lines and groups of studies have not been altered.

The following totals indicate the range and distribution of subjects, with number of hours assigned:

	Recitation	Practicum.
Psychology, philosophy and educatoin, ...	508	746
Language and literature, ...	472	124
History and Political Science, ...	350	
Mathematics, ...	280	
Biology and Botany, ...	244	84
Chemistry, ...	144	236
Physics, ...	144	88
Drawing, Geology, Surveying, Military Tactics,	72	260

Respectfully submitted,

ERWIN W. RUNKLE,
Assistant Professor in Charge.

State College, Dec. 17, 1896.

XVII.—SUB-FRESHMAN (PREPARATORY) CLASS.

To the President:

Sir:—I hereby submit the report of the Sub-Freshman or Preparatory class.

The total number of students enrolled is thirty-eight. Thirty-one are taking the General Science Course, three the Latin-Scientific, and four are pursuing partial courses.

Eighteen different counties of the Commonwealth are represented. Members of the class come from Crawford and Washington counties on the west, from Bedford on the South, from Schuylkill on the east and from Erie, McKean, Potter and Susquehanna on the north. Nearly all of the central counties of the State are represented.

The course of study as given in the catalogue has been closely followed. There have been assigned to Algebra, three sessions; to Geometry, three sessions; to the English classics, one session; to Physics, one session; to Physical Geography, one session. The students pursuing the Latin-Scientific Course in the place of the English Classics, Physics and Physical Geography are taking Latin Grammar, Latin Prose Composition and are reading the work of Caesar and Cicero. Each student has fifteen hours per week of Academic studies, four hours per week of free hand drawing, three hours per week of military drill, and one hour per week of Rhetoricals.

In Rhetoricals each student commits and recites two selections, chosen from standard authors, each session. Upon each selection three rehearsals are given, when the student is drilled in expression, in modulation of voice, in gesture and in position. The student then recites before the entire class. The improvement in this work has been marked and the work should receive every possible encouragement.

At your suggestion Orthography has received attention. During the Fall session two hundred and seventeen words, frequently misspelled, have been listed and carefully learned.

In my judgment a change in the course of study could be made with profit. Physical Geography should be made a requirement for admission. Physics should be pursued two full sessions.

The department is in need of a liberal appropriation. Elementary Physics cannot be satisfactorily taught without apparatus. A complete set of Geometric designs with dividers for accurate construction

of angles, circles, etc., should be supplied. From three hundred to five hundred dollars should be set apart at once for this purpose.

One of the class-rooms assigned to this department should be reseated. The seats with desks, now in use, are conducive to the formation of improper habits of sitting. Dignified positions both in sitting and standing should be required of preparatory students. With the present desks this is well nigh impossible.

Thorough preparation for college work is the aim of this department. A successful preparation requires earnest and constant drill. Preparatory days are the great drill days. As a student advances in educational work he is better able to arrive at truth by hints and suggestions. Lectures may suffice for the trained scholar but the beginner must have opportunity for frequent personal recitations and reviews. The well known pedagogical principle expressed by Dr. Laurie must here have full sway, viz: that 'to complete the impression there must be the expression and that the former is incomplete without the actuality of the latter. Thorough drill is therefore given in all the subjects of the course.

The question is often asked: "Is the Sub-Freshman class a necessity? Why cannot the High Schools of the State prepare for freshman work?" A proper High School can prepare for college. In the school system of Pennsylvania there should be a continuous development from the lowest primary grade to the highest department of college and university. There should be no gaps, no overlapping of studies. Students should not be required to retake subjects thoroughly pursued and mastered either at our High or Normal schools. It should be the constant aim of school men and legislators to give our school system such a continuity that schools and subjects may so succeed one another that precious time may not be wasted, that young men and young women may be prepared for their life's work at the earliest possible moment.

If the State of Pennsylvania had the requisite number of High schools and each had the ideal course of study and the proper kind of instruction the preparatory class would be unnecessary. The ideal condition, however, does not exist. There are many communities without an efficient High school. In every such community there are young people with bright minds, eager for higher education. They are not prepared for college work. The preparation cannot be obtained at home and the question comes to them "Where can it be obtained?" The Sub-Freshman class at The Pennsylvania State College answers the question. It is both natural and advisable that young people who find their home schools inadequate should finish their preparation in the preparatory department of their chosen college. The Sub-Freshman class has done and will, we believe, continue to do, excellent work for the college and for the State.

Studies that can be pursued with advantage in all the public schools should not be included in our course. For admission to this department we would emphasize the fact that students should be thoroughly prepared in English Grammar, Physiology, Geography, both political and physical, U. S. History and in the essentials of Arithmetic, especially emphasizing common and decimal fractions, denominate numbers and including a thorough knowledge of the metric system, interest and square and cube root.

I am indebted to the suggestions and hearty co-operation of the President and to the heads of the various departments of the College. I take this opportunity of acknowledging this indebtedness.

Respectfully submitted,

MARTIN G. BENEDICT,
Officer in Charge.

State College, Pa., Dec. 3, 1896.

ENGINEERING BUILDING—WEST SIDE.

TREASURER'S REPORT.

State College, Pa., July 1, 1896.

To the Board of Trustees of The Pennsylvania State College:

Gentlemen: The following report of the Treasurer of the College is respectfully submitted. By resolution of the Board the date for closing the books and accounts of the College was changed from December 31, to June 30. This report therefore includes only the six months from January 1st, 1896, to June 30th, 1896. The accounts of the College are kept under eight separate heads:

1. The College General account.
2. Eastern and Western Experimental Farm interest account.
3. State appropriation of 1887.
4. State appropriation of 1893.
5. State appropriation of 1895.
6. United States account of 1890.
7. The Agricultural Experiment Station General account.
8. The United States Agricultural Experiment Station account of 1887.

The College General Account.

Dr.

To balance in hands of Treasurer January 1, 1896,	$440 17	
To amount received from Land Scrip Fund,	15,000 00	
To proceeds of notes discounted,	3,000 00	
To amount received from students and from all other sources,	10,067 50	

Cr.

By cash paid College expenses,		$27,469 98
By balance in hands of Treasurer June 30, 1896,		1,037 69
	$28,507 67	$28,507 67

EASTERN AND WESTERN EXPERIMENTAL FARM INTEREST.

Dr.

To balance in hands of Treasurer January 1, 1896,	$1,561 52	
To State Treasurer, one year's interest,	510 00	
Cr.		
By cash College bills paid,		$5 76
By balance in hands of Treasurer June 30, 1896,		$2,065 76
	$2,071 52	$2,071 52

STATE APPROPRIATION, 1887.

Dr.

To balance in hands of Treasurer January 1, 1896,	$192 81	
Cr.		
By cash College bills paid,		$22 92
By balance in hands of Treasury June 30, 1896,		169 89
	$192 81	$192 81

STATE APPROPRIATION OF 1893.

Dr.

To balance in hands of Treasurer January 1, 1896,	$318 49	
Cr.		
By cash paid College expenses,		$253 11
By balance in hands of Treasurer June 30, 1896,		65 38
	$318 49	$318 49

STATE APPROPRIATION OF 1895.

Dr.

To balance in hands of Treasurer January 1, 1896,	$2,545 78	
To amount received from State Treasurer (appropriation),	42,181 98	
To bills payable,	3,000 00	

Cr.

By cash paid College expenses,		$43,921 74
By balance in hands of Treasurer June 30, 1896,		3,806 02
	$47,727 76	$47,727 76

UNITED STATES COLLEGE ACT OF 1890.

Dr.

To balance in hands of Treasurer January 1, 1896,	$569 23	

Cr.

By cash College bills paid,		$550 33
By balance in hands of Treasurer June 30, 1896,		18 90
	$569 23	$569 23

THE AGRICULTURAL EXPERIMENT STATION, GENERAL ACCOUNT.

Dr.

To notes discounted,	$3,200 00	
To receipts from fertilizer analyses,	6,129 50	
To receipts from all other sources,	3,709 87	

Cr.

By balance due the Treasurer January 1, 1896,		$862 63
By cash paid by the Treasurer, bills, etc.,		11,305 45
By balance in hands of Treasurer June 30, 1896,		871 31
	$13,039 39	$13,039 39

THE UNITED STATES AGRICULTURAL EXPERIMENT STATION APPROPRIATION, 1887.

Dr.

To balance in hands of Treasurer January 1, 1896,	$1,237 69	
To amount received from United States Treasurer,	7,500 00	

Cr.

By cash paid Station bills,		$8,706 44
By balance in hands of Treasurer June 30, 1896,		31 25
	$8,737 69	$8,737 69

SUMMARY.

College Accounts.

Dr.

Total in hands of Treasurer January 1, 1896,	$5,628 00	
Total received up to June 30, 1896,	73,759 48	
Cr.		
By amount expended up to June 30, 1896,		$72,223 84
By balance in hands of Treasurer June 30, 1896,		7,163 64
	$79,387 48	$79,387 48

Experiment Station.

Dr.

Total in hand January 1, 1896,	$375 06	
Total received up to June 30, 1896,	20,539 39	
Cr.		
Total expended up to June 30, 1896,		$20,011 89
Balance on hand June 30, 1896,		902 56
	$20,914 45	$20,914 45

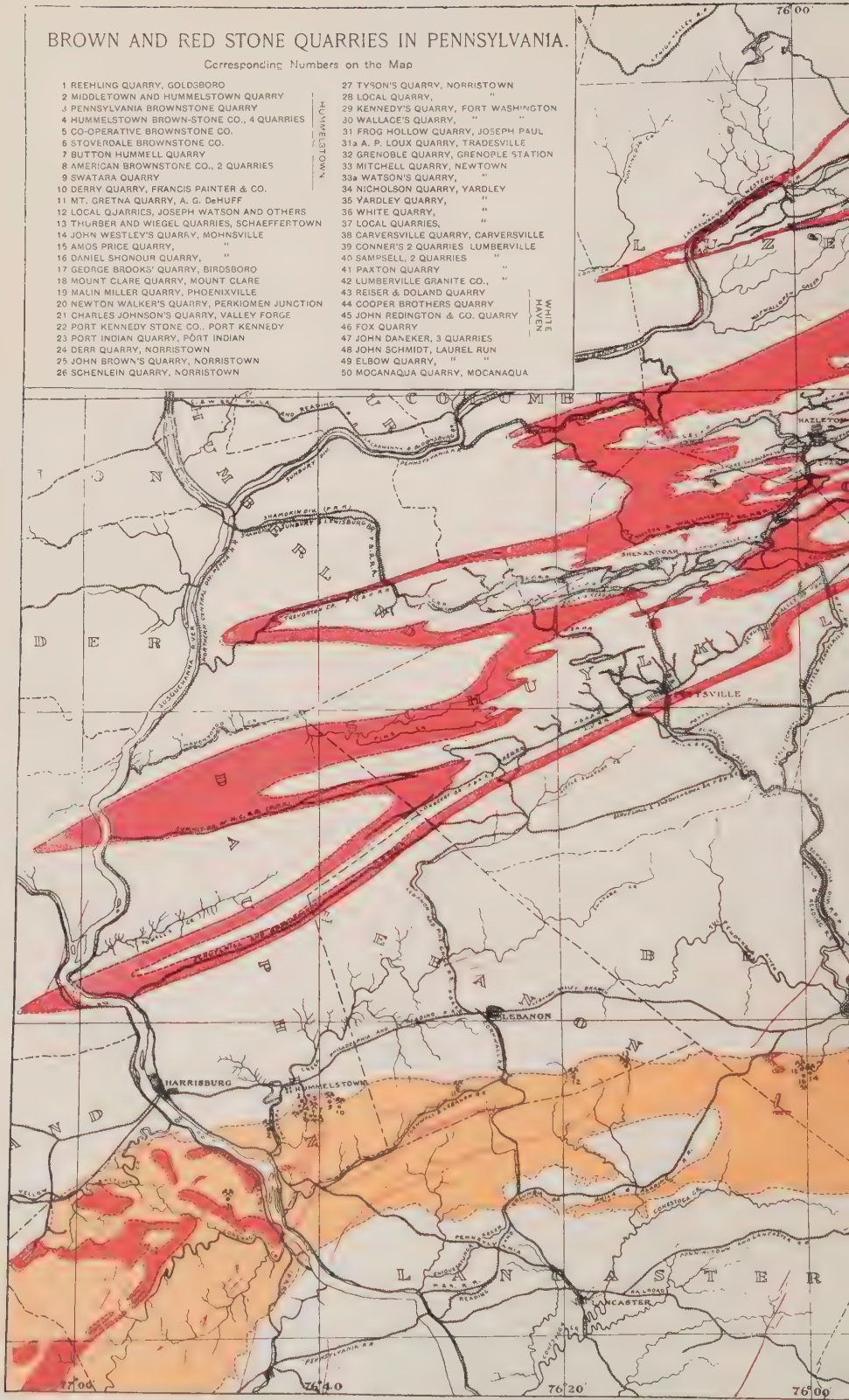
Dr.

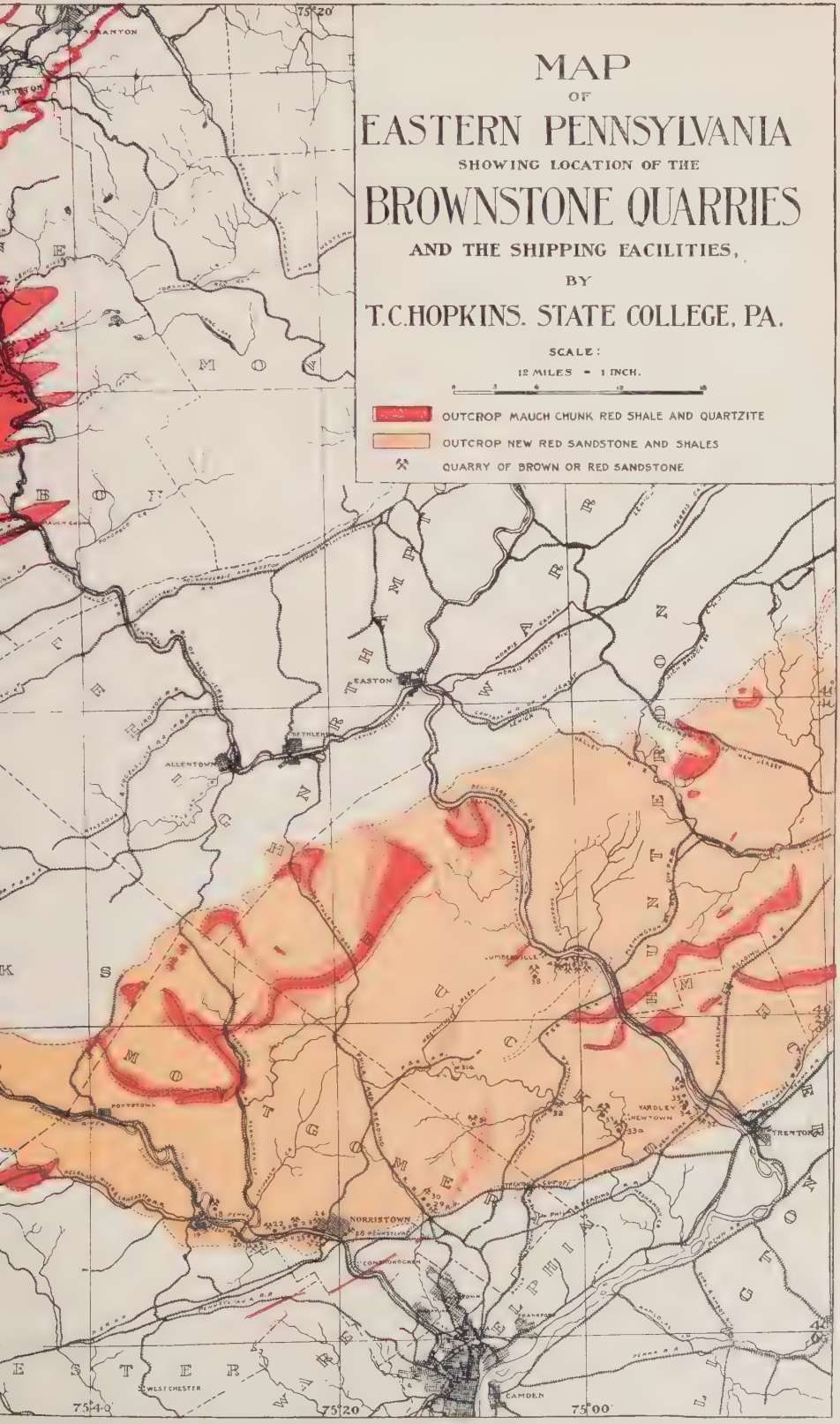
Total receipts, including balance on hand January 1, 1896,	$100,301 93	
Cr.		
Total expended to June 30, 1896,		$92,235 73
Balance on hand June 30, 1896,		8,066 20
	$100,301 93	$100,301 93

Respectfully submitted,

JOHN HAMILTON,

Treasurer of The Pennsylvania State College.


BROWN AND RED STONE QUARRIES IN PENNSYLVANIA.
Corresponding Numbers on the Map
1 REEHLING QUARRY, GOLDSBORO
2 MIDDLETOWN AND HUMMELSTOWN QUARRY
3 PENNSYLVANIA BROWNSTONE QUARRY
4 HUMMELSTOWN BROWN-STONE CO., 4 QUARRIES
5 CO-OPERATIVE BROWNSTONE CO.
6 STOVERDALE BROWNSTONE CO.
7 BUTTON HUMMELL QUARRY
8 AMERICAN BROWNSTONE CO., 2 QUARRIES
9 SWATARA QUARRY
10 DERRY QUARRY, FRANCIS PAINTER & CO.
11 MT. GRETNA QUARRY, A. G. DeHUFF
12 LOCAL QUARRIES, JOSEPH WATSON AND OTHERS
13 THURBER AND WIEGEL QUARRIES, SCHAEFFERTOWN
14 JOHN WESTLEY'S QUARRY, MOHNSVILLE
15 AMOS PRICE QUARRY, "
16 DANIEL SHONOUR QUARRY, "
17 GEORGE BROOKS' QUARRY, BIRDSBORO
18 MOUNT CLARE QUARRY, MOUNT CLARE
19 MALIN MILLER QUARRY, PHOENIXVILLE
20 NEWTON WALKER'S QUARRY, PERKIOMEN JUNCTION
21 CHARLES JOHNSON'S QUARRY, VALLEY FORGE
22 PORT KENNEDY STONE CO., PORT KENNEDY
23 PORT INDIAN QUARRY, PORT INDIAN
24 DERR QUARRY, NORRISTOWN
25 JOHN BROWN'S QUARRY, NORRISTOWN
26 SCHENLEIN QUARRY, NORRISTOWN
27 TYSON'S QUARRY, NORRISTOWN
28 LOCAL QUARRY, "
29 KENNEDY'S QUARRY, FORT WASHINGTON
30 WALLACE'S QUARRY, " "
31 FROG HOLLOW QUARRY, JOSEPH PAUL
31a A. P. LOUX QUARRY, TRADESVILLE
32 GRENOBLE QUARRY, GRENOBLE STATION
33 MITCHELL QUARRY, NEWTOWN
33a WATSON'S QUARRY, "
34 NICHOLSON QUARRY, YARDLEY
35 YARDLEY QUARRY, "
36 WHITE QUARRY, "
37 LOCAL QUARRIES, "
38 CARVERSVILLE QUARRY, CARVERSVILLE
39 CONNER'S 2 QUARRIES LUMBERVILLE
40 SAMPSELL, 2 QUARRIES "
41 PAXTON QUARRY "
42 LUMBERVILLE GRANITE CO., "
43 REISER & DOLAND QUARRY
44 COOPER BROTHERS QUARRY
45 JOHN REDINGTON & CO. QUARRY
46 FOX QUARRY
47 JOHN DANEKER, 3 QUARRIES
48 JOHN SCHMIDT, LAUREL RUN
49 ELBOW QUARRY, " "
50 MOCANAQUA QUARRY, MOCANAQUA
HUMMELSTOWN
WHITE MARBLE
76°00'
HAZLETON
SHENANDOAH
TSVILLE
LEBANON
HARRISBURG
HUMMELSTOWN
LANCASTER
77°00'
76°40'
76°20'
76°00'


MAP
OF
EASTERN PENNSYLVANIA
SHOWING LOCATION OF THE
BROWNSTONE QUARRIES
AND THE SHIPPING FACILITIES,
BY
T.C.HOPKINS. STATE COLLEGE, PA.
SCALE:
12 MILES = 1 INCH.
0 3 6 12 18
OUTCROP MAUCH CHUNK RED SHALE AND QUARTZITE
OUTCROP NEW RED SANDSTONE AND SHALES
QUARRY OF BROWN OR RED SANDSTONE
75°20'
75°40'
75°00'
SCRANTON
EASTON
ALLENTOWN
NORRISTOWN
TRENTON
CAMDEN
WESTCHESTER
POTTSTOWN
YARDLEY
NEWTOWN
LEHIGH
NORTHAMPTON
BUCKS
MONTGOMERY
DELAWARE
CHESTER
BERKS
SCHUYLKILL
LEBANON
LANCASTER
YORK
DAUPHIN
PHILADELPHIA

THE BUILDING MATERIALS

OF

PENNSYLVANIA.

I.—BROWNSTONES,

BY

THOMAS C. HOPKINS, M. S., M. A.,

Assistant Professor of Economic Geology in The Pennsylvania State College.

APPENDIX
TO THE ANNUAL REPORT
OF
PENNSYLVANIA STATE COLLEGE
FOR 1896.

VIRTUE
LIBERTY AND

LETTER OF TRANSMITTAL.

Sir: In accordance with instructions from you, I have prepared the following report on the brownstones of Pennsylvania. The brief time allotted to this work necessarily prevented as complete and detailed a report as the subject really demands, but as the value of such a report is greatly enhanced by its prompt appearance, it is here presented, trusting that so far as complete it may fill an urgent need. It would be desirable to have an accurate map of the region showing the location of the quarries and of the outcrops of good stone, which could not be done in one season, and the accompanying map is the best that could be made in the time.

The aim has been to emphasize the economic side of the question and practically all the time was given to that phase of the subject, as the little work that has hitherto been done has been rather in the line of pure science, and while there is need and opportunity for more work on such lines, such as the determination of the age of the New Red, its total thickness, history, etc., the most urgent need at present is information on the economic side, and it is such that we have endeavored to supply.

The people of the State, as a rule, do not realize the local value and importance of these sandstone deposits, nor in fact of many of the other valuable building stones of the State. Quite frequently the large part of the cost of a stone building is in freight rates on stone, not uncommonly on a stone inferior to one near home, the existence of which appears to be unknown or at least unrecognized. This oversight may be to a certain extent due to the architects but not largely so, as the architects cannot be expected to make a personal investigation of all the undeveloped stone regions, which is work that should very properly come under the province of the State and expenditure on this line would no doubt be rewarded in the greater development and use of our native stone. A considerable percentage of the stone used in the State at the present time comes from the Indiana and Ohio quarries. While there may not be equally extensive deposits of good stone in this State, there may be stone equally good in smaller deposits which could be used to advantage if its location and qualities were known. The Indiana stone costs at the quarries ten to thirteen cents per cubic foot; the freight rate

to Philadelphia is more than double that; thus $1,000 worth of stone costs $2,500 to transport it, so that we pay $3,500 in Pennsylvania for $1,000 worth of Indiana stone. Supposing it costs double the amount to quarry the stone in this State that it does to quarry it in Indiana there would still be a saving in using home stone to say nothing of the increased wealth to the State.

The other sandstones, the limestone, marble, serpentine, trap, and granite rocks are all susceptible of a more extended use than they have at present.

The demand at present is for a light colored stone and while I believe it not only possible but probable that there is sufficient stone of good quality of this kind in the State to supply at least the local demand, if not that of outside markets, it is not possible with the present knowledge to direct any one desiring such stone to a place where he can obtain it. Until that can be done stone will continue to be brought in large quantities from other states to meet the demand. Investigation in the State along these lines ought certainly be a most profitable investment.

I found quarrymen in New Jersey making inquiries about a light colored sandstone in Clearfield county, stating that it was one of their chief rivals in the eastern markets, yet we find no mention of this stone in any of the state reports.

The stone wealth of this State is greater than that of any other state in the Union, yet less has been done towards investigating and making known to the people the occurrence and quality of this great source of wealth, than in many of the others.

Any one seeking information concerning the quantity, variety, occurrence and value of the building stones of the State in either official or private publications will be surprised at the paucity of such information. The demand for such data led to the preparation of this report.

Permit me to thank you for your kindly interest and help in this work and to acknowledge the uniform kindness and courtesy of the stone dealers throughout the area traversed.

Respectfully submitted,

T. C. HOPKINS.

To the President, State College, Pa.,

January 16, 1897.

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OBELISK ILLUSTRATING BUILDING MATERIALS OF PENNSYLVANIA.

BROWNSTONES OF PENNSYLVANIA.

BY T. C. HOPKINS

PART I. THE GENERAL FEATURES OF BROWNSTONES.

Introductory.— Brownstones are among the oldest, best known and handsomest building stones used in this country. The brownstone fronts of New York and other eastern cities are found in the most fashionable parts of the cities and in great numbers. It is true that some years ago the use of brownstone was a fad, so much so that all the quarries running to their full capacity could not supply the demand. As a result its use was carried to excess, not only in the use of much inferior stone, but in the monotonous architecture resulting from long blocks of gloomy brownstone houses with no mingling of colors and little variety of form.

The extent to which brownstone was formerly used in New York is shown in the 10th census report, 1880, in which it is stated that of the stone buildings in New York city 78.6 per cent. consists of brownstone, which included 9,143 brownstone buildings in the city proper and 19,154 in the city and the suburbs, of which 79 were entirely of stone, the remainder with stone fronts. While the percentage in Philadelphia was not given, it would probably be much less. A writer in *Stone* less than two years ago (July, 1895), says that brownstone has not gone out of fashion, that as a matter of fact as much brownstone is being used in New York to-day as ever in the past, a statement which can hardly be substantiated, as a reaction has now set in, and the craze is for light stone. As a result we shall have in a few years monotonous blocks of light-colored limestone, marble and sandstone. By the time this second climax is passed, a more rational mode of procedure will prevail, architects and builders will begin to use stone that will harmonize with the plan and style of the building and with its location and surroundings. Then good building stone of different kinds and different colors will be in demand. Then the use of brownstone will again increase, as it is a useful and valuable building stone, one of the best if properly used and not abused.

Reliable information on the different brownstones is very scarce and widely scattered, so that one desirous of information in regard

to the quality and accessibility of the brownstones in different localities is at a loss to know where to turn. It is with the desire partially to fill this want that the present report is written, It is intended primarily for the Pennsylvania brownstones, but the chief commercial features of the brownstones from other states so far as could be obtained are given. Most of the ones mentioned come into competition with Pennsylvania brownstones in the markets both in this and in other states.

The aim has been in this report not to follow beaten paths, but to give such information and data concerning our brownstones, in as plain terms as possible, as would be of service to present and prospective quarrymen, to present and prospective buyers and dealers, and to the general reader. A state has not only a right but a duty to make known its own resources; that is, to make accessible to the reading public such data in regard to the occurrence, distribution and properties of its natural products as will lead to their more intelligent use.

Literature on Pennsylvania Brownstones.—Much has been written on the paleontology and some historical features of the eastern brownstones and published in the various journals and proceedings of scientific societies. These papers are all enumerated and classified in Bull. 85 of the U. S. Geol. Survey, The Newark System, by I. C. Russell, and only those few that have any bearing on the economics of the Pennsylvania brownstones are enumerated below. All of these are very brief, very general and, with one exception, local. There may possibly be a few other references to the occurrence of the brownstone in other reports of the Pennsylvania Geological Survey, but none that have any bearing on the economic side of the question. Merrill's work on Building Stones and the 10th Census Report referred to below describe briefly the building stones in all the states. Reference to articles on the brownstones of the different states are given under the name of the state where they are described in the text.

1. D'Invilliers, E. V.—Annual Report, Second Geological Survey of Pennsylvania, 1886, part iv. Paint, Iron Ore, Limestone and Serpentine, pp. 1563-1567. Brief description of the brownstone quarries in the vicinity of Hummelstown.

2. Frazer, Persifor.—Report of a Geological Survey of Chester County, Pennsylvania Geological Survey, CCCC, 1880, pp. 178-214.—The stratigraphic and paleontologic relations of the Mesozoic red sandstones in Chester County.

3. Frazer, Persifor, Jr.—The Geology of Lancaster County. Second Geological Survey of Pennsylvania, 1877, CCC, mentions the occurrence of the New Red sandstone in Lancaster County.

4. Lyman, Benj. Smith.—Report on the New Red of Bucks and Montgomery Counties, in Summary Final Report Geology of Pennsylvania, Vol. III, Part 2, pp. 2589-2638, 1895. Gives geological and topographical map of the New Red of Bucks and Montgomery Counties, with a detailed account of the stratigraphy, paleontology and general scientific features, and brief mention of the economic features.

5. Merrill, G. P.—Stones for Building and Decoration, Wiley & Sons, N. Y., 1891, pp. 279-281. Also in Smithsonian Report, Part 2, 1886.

Shaler, N. S.—Description of Quarries and Quarry Regions, 10th Census, Volume X, pp. 156-157. One of the best short descriptions of the brownstones of Pennsylvania.

Definition.—It might at first glance seem superfluous to offer a definition to such a simple term as brownstone, but the very fact that it is used with different meanings in the market is reason why it is advisable to state the significance of the word as used in this report.

If all the brownstones occurred in one locality and were all one shade of color, the term would be self-explanatory, but stone varying from gray, through all shades of yellow, red and brown, to black occurs in a dozen or more states, and in several different geologic horizons. The term brownstone in some localities is a synonym for the stone from Portland, Connecticut, because that is used in such large quantities, and no other is used at that point. With some persons brownstone signifies any rock from the Mesozoic or New Red formation, whether it be really brown or not. In this report the term is used for any stone that has a brown or red color, irrespective of locality or the geological formation in which it occurs. It also includes a light stone, which is not strictly brown except in places, but which occurs in the New Red formation, because it is so closely associated with brownstone, often in the same quarry, and because it commonly passes in the market as brownstone. Much of the Trenton brownstone in the market is not really brown, but gray, yet brownstone may come from an adjoining, often from the same, quarry. There is also included red or brown stone from the Paleozoic rocks, which may not be generally known in the market under the name brownstone, but which is as truly brown in color as many of the Mesozoic brownstones. Hence the term is here used to designate a sandstone with a brown or red color rather than a brownstone from any particular locality or formation. The red or brown marbles are not included.

Colors.—Brown is defined as a dark color shading towards red, yellow or black, and may be produced by a mixture of these colors.*

*Standard Dictionary

We can thus see that there may be an almost infinite number of shades of brown, grading insensibly into red, yellow or black, and that there may be wide divergence of opinion as to where the division should be made. In the sandstones the change is most frequently towards the red, less commonly to the yellow. So close is the relation that the same stone is called by some dealers red and by others brown.

The color is almost wholly due to the oxides of iron, the yellow and yellow-brown to the hydrous oxide and the red and red-brown to the anhydrous form. The shade of color depends partly on the hydration of the iron, partly on the fineness of the particles and the manner of their distribution. A small percentage of manganese affects the color in some localities, the tendency of the manganese oxides being to give a purplish tint.

From the standpoint of color, brownstone is one of the best of building stones, not only because of the wide range of shades to select from, but from the inherent beauty and richness of many of the shades, and what is of great importance in architecture, the permanency of the color. There is probably not another color common among building stones that is as permanent and as little liable to tarnish as brown. In some brownstone buildings that have been standing nearly 100 years the stone is as bright as when it first came from the quarry.

Where brownstone is used to excess, particularly dark shades, and along narrow streets, it is gloomy and sombre. It is used to best advantage in combination with other colored building stones, or at least with a more general use of lighter brownstones. The darker colored stones, while more sombre than the lighter shades, show the dirt and stains of the city atmosphere less and are in this respect better adapted to base-courses and trimmings. The inherent beauty and permanency in the color, together with its desirability in combination with stones of other colors for architectural effect, will always cause a demand for brownstone by the best architects.

The brownstones of Pennsylvania have as wide a range in color as those of any other state. There is the rich purple-brown and red-brown at Hummelstown, the dark brown at Mohnsville, the light, warm, red-brown at Cornwall, the light purplish brown at Newtown and Yardley, the very light brown to gray at Lumberville, Grenoble and Fort Washington, the light pink south of Birdsboro, and the light red and dark red at White Haven and Laurel Run.

The chemical composition of brownstones.—The accompanying table of analyses giving the chemical composition of all the well-known brownstones in this country so far as they could be obtained. The first table gives those of Pennsylvania, the second those from other states for comparison. It may be noticed in comparing these that

the Hummelstown stone corresponds more nearly with that of East Longmeadow, Massachusetts, than any other. The one analysis of the Hummelstown stone (No. 9) corresponds very closely with one from East Longmeadow (No. 14), the Worcester quarry "brown stone," but the other Massachusetts specimen (No. 15); from the Maynard quarry "red stone," is much lower in silica, higher in alumina and lime and much higher in alkali, indicating more feldspar, and possibly mica.

The stones of the eastern part of the State more nearly resemble the New England brownstones than those farther west in the State, but even they have a high percentage of silica, a lower percentage of alumina and a much lower percentage of alkali than the New England brownstones.

The signification of the varying proportions of the different substances is not always perfectly clear, but a number of very useful deductions can be made as follows: of all the substances mentioned silica is the most durable, especially if it occurs in the form of quartz. It is desirable to have the percentage of silica as high as is consistent with the desired hardness and workability of the stone. That is, from the standpoint of durability alone quartz is the most desirable substance, but if the silica is all in quartz grains and the percentage too high the stone will be friable, from not having sufficient cement to hold the grains together; on the other hand, if part

Analyses of Pennsylvania Brownstones.

No.	Location of Quarry.	Specific gravity.	Silica SiO_2.	Alumina Al_2O_3.	Ferric Oxide Fe_2O_3.	Ferrous Oxide FeO.	Lime CaO.	Magnesia MgO.	Manganic Oxide Mn_2O_3.	Potash K_2O.	Soda Na_2O.	Water H_2O	Total.
1	Hummelstown Brownstone Co.—Blue	2.657	90.34	4.35	1.09	.74	.95	.17	.....	1.30	.13	.61	99.74
2	Hummelstown Brownstone Co.—Brown,	2.669	88.96	4.74	2.19	.....	.86	.44	.....	1.31	.24	.87	99.61
3	Swatara Brownstone Co.	.....	91.52	3.80	2.02	.....	.50	.22	.....	(1)1.20	.....	.74	100.00
4	Mt. Gretna,	2.695	91.07	2.68	3.29	.....	.23	.33	.....	1.12	.24	.73	99.68
5	Westley's quarry, Mohnsville,	2.73	84.96	7.78	3.71	.....	.10	.35	.18	1.11	.43	1.40	100.05
6	Grenoble Station,	2.66	79.08	12.42	2.50	.....	.....	.....	.09	2.02	3.01	.55	99.67
7	Mitchell's quarry, Newtown	2.66	82.34	11.46	1.07	.....	.27	.19	.07	.17	3.76	.89	100.13
8	Yardley quarry, Yardley,	2 675	82.72	10.29	1.92	.....	.17	.36	.16	.10	2.92	1.20	99.84
9	Hummelstown,	.....	88.13	5.81	1.77	.31	.20	.33	.....	2.63	.06	.49	99.93
10	Laurel Run red stone, Laurel Run,	2.656	(2)94.00	tr.	1.98	.....	1.10	1.00	tr.	.....	.....	(3)1.92	100.00
11	Daneker's quarry, White Haven,	.....	90.36	2.17	(4)1.15	.....	2.00	tr.	.....	.....	.....	.....	95.68

Analyses 1 to 8 inclusive made in Chemical Laboratory, State College, Pa. No. 9 by E. A. Schneider. Bull. 90 U. S. Geol. Surv., p. 65. No. 10 by A. A. Brenaman, N. Y. No. 11 Crane Iron Co's. Laboratory.

(1) Includes alkalies and loss.
(2) Silica and insoluble residue.
(3) Volatile matter—water and carbonic acid.
(4) Given as protoxide evidently a mistake.

Analyses of Brownstones.

No.	Locality.	Silica SiO_2.	Alumina Al_2O_3.	Iron oxide FeO.	Lime CaO.	Magnesia MgO.	Alkalies K_2O, Na_2O.	Water.	Total.	Authority.
12	Portland, Ct.,	69.94	13.15	2.48	3.09	tr.	8.73	(1)1.01	.....	Merrill building and ornament stones, p. 420.
13	Cromwell, Ct.,	70.11	13.49	4.85	2.39	1.44	7.37	.....	100.00	
14	E. Longmeadow, Mass., "Worcester quarry,"	70.84	13.15	2.48	3.09	tr.	8.73	1.01	100.00	N. E. Brownstone Co.
15	E. Longmeadow, Mass., "Maynard quarry,"	88.89	5.95	1.79	.27	.....	.86	(1)1.83	100.00	Worcester Polytechnic Institute.
16	Wilburtha, N. J.,	79.38	8.75	2.43	2.57	.....	4.08	(1)2.79	100.00	Worcester Polytechnic Institute.
17	Wilburtha, N. J.,	93.55	4.00	.....	.40	.18	.30	.12	99.63	Geol. of New Jersey, 1868, p. 515.
18	Milford, N. J.,	93.60	1.59	3.30	.....	.....	.35	1.20	100.04	Geol. of New Jersey, 1868, p. 516.
19	Centre Bridge, N. J.,	79.25	7.49	3.78	1.86	.....	1.12	3.16	(3)99.51	Geol. of New Jersey, 1868, p. 516.
20	Washington Valley, N. J.,	96.20	1.58	(2)1.37	.15	.36	.....	1.15	98.59	Geol. of New Jersey, 1868, p. 515.
21	Hancock, Maryland,	88.45	3.92	3.03	.36	.12	.88	1.80	98.70	Geol. of New Jersey, 1868, p. 515.
22	Hancock, Maryland,	76.43	17.78	.....	.84	.92	.....	.....	98.76	Bulletin 55 U. S. G. S., page 80.
23	Sanford, N. C., brown,	(4)88.68	.....	7.13	1.32	.....	.....	2.20	.....	Bulletin 55 U. S. G. S., page 80.
24	Sanford, N. C., red,	81.59	10.81	4.38	1.02	.33	1.08	.79	100.00	Garrett & Dix, Philadelphia.
25	Mansfield, Ind.,	82.58	8.95	3.95	1.18	.81	.83	1.68	100.00	Garrett & Dix, Philadelphia.
26	St. Anthony, Ind.,	(5)92.16	.....	6.29	.05	.....	.09	.....	98.59	Rose Polytechnic Institute.
27	Bloomfield, Ind.,	(5)88.41	.63	8.40	.13	.....	.....	.....	97.57	Rose Polytechnic Institute.
28	Greenhill, Ind.,	(5)85.29	.19	11.83	.06	.....	.....	.....	97.43	Rose Polytechnic Institute.
29	Hillsboro, Ind.,	98.73	.28	.36	.03	.....	.....	.....	99.40	Rose Polytechnic Institute.
30	L'Anse, Mich.,	(5)91.65	.56	6.60	.12	.....	.....	.....	98.93	Rose Polytechnic Institute.
31	Portage Entry, Mich.,	78.55	14.21	5.54	.42	tr.	.....	.....	.....	
32	Portage Entry, Mich.,	90.17	4.23	3.16	.....	.29	.....	1.01	100.00	Mariner & Hoskins, Chicago.
33	Marquette, Mich.,	82.60	8.32	.28	.55	.18	6.49	.99	99.80	Report Geol. Surv. Mich., 1891-2.
34	Keweenaw Bay, Mich.,	77.18	9.69	3.20	0.26	1.48	4.85	2.90	(6)100.00	F. F. Sharpless.
35	Houghton, Wis.,	78.55	14.21	5.54	.42	tr.	.....	1.28	100.00	Stone, Vol. IX, No. 1.
36	Bass Island, Wis.,	91.40	3.53	2.00	.25	.....	2.50	.05	99.73	Columbia College School of Mines.
37	Fond du Lac., Minn.,	87.02	7.17	3.91	.11	.06	1.66	.....	99.92	Geol. of Wis., Vol. III, page 208.
38	Flagstaff, Ariz.,	78.24	10.88	3.83	.95	1.60	1.72	.....	97.23	Geol. of Minn., Vol. I, page 202.
39	Kettle River, Minn.,	79.15	1.30	2.45	7.76	.23	.....	3.26	(7)99.96	Bull. 78, U. S. G. S., p. 124.
40	Pipestone, Minn.,	98.69	1.06	tr.	.42	.01	.17	.....	.....	N. H. Winchell.
		84.52	12.33	2.12	.34	tr.	.45	(1)2.31	.....	

(1) Includes water, CO_2, and loss. No. 14 contains 0.41 per cent. manganese dioxide.
(2) Iron given as protoxide.
(3) Includes also sulphuric acid 1.39 per cent. and carbonic acid 1.46 per cent.
(4) Insoluble residue. No. 21 is analysis of the same as 22, in which all the silica is determined by fusion with soda carbonate. Both from the Jaitelle quarry.
(5) Insoluble residue includes silica and insoluble silicates.
(6) Includes P_2O_5 0.21 per cent. and SO_3 0.23.
(7) Includes 5.77 CO_2 analyzed by T. M. Chatard.

of the silica is in the form of cement binding the grains together, the stone is liable to be too hard to work. Hence, no definite limit can be placed on the amount of silica allowable in a good stone, as that depends on whether a hard stone or easy-working stone is desired, and also on how much of the silica is in feldspar, mica or clay,—the proportions of alkali, lime and alumina throw much light on this point. It also depends on the size and shape of the grains; thus round grains require more and stronger cement than sharply angular grains to produce a stone equal in strength; irregular angular grains when closely compact will make a very strong stone with very little cement, because of the interlocking of the grains among themselves.

A high percentage of alumina is not desirable; if in the form of feldspar or mica it is a source of decay; if in the form of clay it will absorb water and injure the stone by freezing. The last injury is intensified if the clay is segregated in patches or layers. On the other hand, a certain percentage of clay is desirable to make an easy-working stone. If the cement is entirely or largely quartz or calcite the stone will be too hard to work freely. No arbitrary standard can be given for the maximum percentage of alumina allowable, as that depends on the form in which it occurs, the manner of its distribution, the shape of the grains and the desired use of the stone.

The iron oxide is desirable within reasonable limits, providing it occurs in the peroxide form, as it gives the color to the stone and forms a strong and durable cement. It generally occurs associated with more or less clay. If the iron occurs in the form of pyrite or carbonate it is liable to be a source of disintegration. It is customary in making the analysis to determine the iron as peroxide without proving it to be such. Hence the small percentage of protoxide given with the Hummelstown stone does not signify that it does not occur in any of the others, but simply that it was not determined in any of the others, and that it does not occur in sufficient quantities in the Hummelstown stone to be any serious injury to the stone, as might be suggested by its blue color.

The lime is not a desirable element. It is probably less injurious in the form of feldspar (the form in which much of it occurs in the analyses given) than in the form of calcite, as in the latter case it hardens the stone; where it does not form all the cement it hardens it unequally, and is, furthermore, more soluble than the other substances, and is in that way a source of weakness. In the first instance the only injury is in the presence of the feldspar, which is liable to decay.

The alkalies are not desirable substances on account of their solubility. In the fresh feldspar they are insoluble, but in most of the sandstone the feldspars are more or less decayed, and as they decay

the alkalies go in solution and frequently act on the other substances. The white efflorescence sometimes seen on the face of the sandstone outcrops is due (in many cases, at least) to the alkali salts from the decaying feldspars.

Mineralogical composition of brownstone.—The mineralogical composition is frequently as valuable an indication of the quality of the stone as the chemical composition, and sometimes more so, especially when combined with a microscopic examination, which shows not only the minerals present, but the relative quantity and the condition in which they occur. The bulk of all sandstones is made up of quartz grains, which generally form from 70 to 95 per cent of the rock. In the quartzites the grains are cemented by quartz deposited in the interstices, thus giving a high percentage of silica. However, a high percentage of silica does not always signify a quartzite, as may be seen on comparing a few analyses in the foregoing tables. Thus, the Mt. Gretna and the Hockersville stone each show a percentage of more than 91 per cent silica, while the White Haven stone has less than 91 per cent, yet the first two, especially the Mt. Gretna stone, are friable sandstones, and the last a hard quartzite. Likewise the Wilburtha stone, which has 93 per cent. silica, is a soft stone, and the Mansfield, Indiana, stone, with more than 92 per cent. silica is a friable sandstone, and the Lumberville stone, which is a hard quartzite, has less than 80 per cent. silica. The advantage of the microscopic examination over the chemical or rather in combination with the chemical, is that it shows the form in which these elements occur. Thus, the Lumberville stone has the grains of quartz and feldspar firmly bound in a quartz cement, which would not be shown by the analysis.

The next most abundant substance after quartz found in the grains of sandstone is feldspar. In some localities orthoclase and microcline, the alkali feldspar, are abundant, while in other places plagioclase, or basic feldspar, predominates As most of the feldspars occur in sandstone in a more or less decayed condition, where plagioclase abounds, calcite is liable to be found in the sandstone, and in many places there is an efflorescence, formed on the stone in protected places, of sodium or potassium sulphate from the alkali of the feldspar. While this efflorescence was observed in many places it was only analyzed from one locality (Port Kennedy), and there it proved to be mirabalite, or glauber salt (sodium sulphate). The resulting products of decaying feldspar are numerous, depending on the conditions under which it decomposes. The most common products are clay, quartz and muscovite (mica). In none of the brownstones examined was muscovite observed in large flakes where it appeared to be a secondary product, but aggregates of clay with much finely granular quartz and minute portions of some highly polarizing mineral that is probably muscovite, are plentiful, some-

times in a rim of feldspar, sometimes with included fragments of partially decayed feldspar; in fact, nearly all stages from fresh looking feldspar to clay in which the outlines of the feldspar have been lost.

Mica which is quite abundant in the New England brownstone is very scarce in the Pennsylvania brownstones, occurring only in a few widely scattered fragments. It readily decomposes, and is an element of weakness, not alone from its disintegration, but likewise from the tendency of the flakes to all lie the same way and make planes of easy cleavage, along which the stone flakes and scales on exposure. The scaling is much worse where the mica is much decayed. It is one of the most injurious minerals that occur in sandstones.

Iron oxide in the form of hematite and limonite occurs diffused through the clay cement, and surrounding many of the grains of sand. It occurs in such a finely divided state that it is impossible in some cases to determine what mineral form it takes. Most of it is presumably red hematite judging from the color of the rock, and in some place small hematite crystals are distinguishable.

Calcite occurs in small quantities in the interstices between the grains in some localities, but in general the percentage is very small. It is most abundant in the hard stone from White Haven and Laurel Run.

Other minerals occur in small quantities, but not in sufficient abundance to affect the durability or character of the stone to any extent. Small crystals of apatite, zirkon and rutile occur in the quartz grains, and small fragments of magnetite, augite, and hornblende were observed. There are likely to be present small fragments of any minerals that occur in the rocks from which the debris was obtained. The contents of the different varieties are given under the headings where they are described.

Structural features of brownstone.—Brownstones vary in structure from fissile shales on one side to massive seamless beds on the other. The thin-bedded stone that occurs in regular layers less than five or six inches thick, if sufficiently hard, is used for flagstone; in irregular layers it has no value except for broken stone or for cellar walls. In many instances quarries that furnish flagstone at the outcrop furnish heavy dimension stone in the interior, the numerous bedding planes being opened by the weathering influence. This is particularly true in the White Haven and the Laurel Run red stone quarries.

As in other sandstones, false bedding or cross-grain is common in the brownstones. Sometimes the flagstone layers are formed by the false bedding planes. (See fig. 1 and plate 26.) The false bedding is

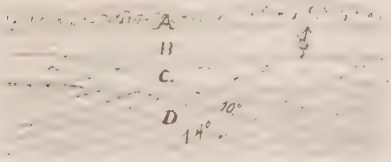


Fig. 1. Section on the face of one of the Laurel Run quarries, showing false bedding or cross-grain. A—Glacial material. B—Heavy bed red sandstone. C—Sandstone with small cavities. D—Cross-bedded red sandstone.

in nearly all cases an injury to the rock causing a great deal of waste, and making the stone difficult to quarry and dress properly. False-bedded stone is nearly always banded and varied in texture, having alternating streaks and patches of fine and coarse grained stone.

If the stone is soft enough to be easily channeled, a massive form entirely free from seams, either bedding seams or wall seams, is the most desirable. If the stone is so hard as to be channeled with difficulty, a certain number of bedding planes or seams is desirable for the economic production of the stone. The lack of sufficient bedding seams is often balanced by the number of joint or wall seams, which are liable to be very abundant if the rock is hard and has been subjected to much folding or pressing. The joint seams are important features in the Lumberville quarries. (See plates 22 and 23.) In some places the joint seams become so abundant as to cause much waste in the rock, and in some instances cut it up into such small dimensions as to ruin it entirely for building stone. The bedding planes are frequently irregular, not even or parallel with each other, thus causing much waste when squaring the blocks; where these irregular seams come close together fine dimension stone cannot be obtained, and the stone can only be used for rough work.

Textural and microscopic features of brownstones. -Like all other sandstones, the brownstones vary in texture, grading from the shales and slates on the one side to the coarse conglomerate or pudding stone on the other, thus forming an intermediate class between these two. The coarse-grained varieties look well in heavy masonry in rock face work, and are better adapted to that line of work, the finer grained being better adapted to fine carving or tool dressed surface, but adapted to rock face work as well. The most desirable texture from a commercial standpoint is one that is homogeneous throughout and not very coarse, but a uniformly coarse-grained stone is better than one having a mixture of fine and coarse grain. As a rule the coarse-grained rocks are more porous and absorb water more freely, and hence are more liable to injury from

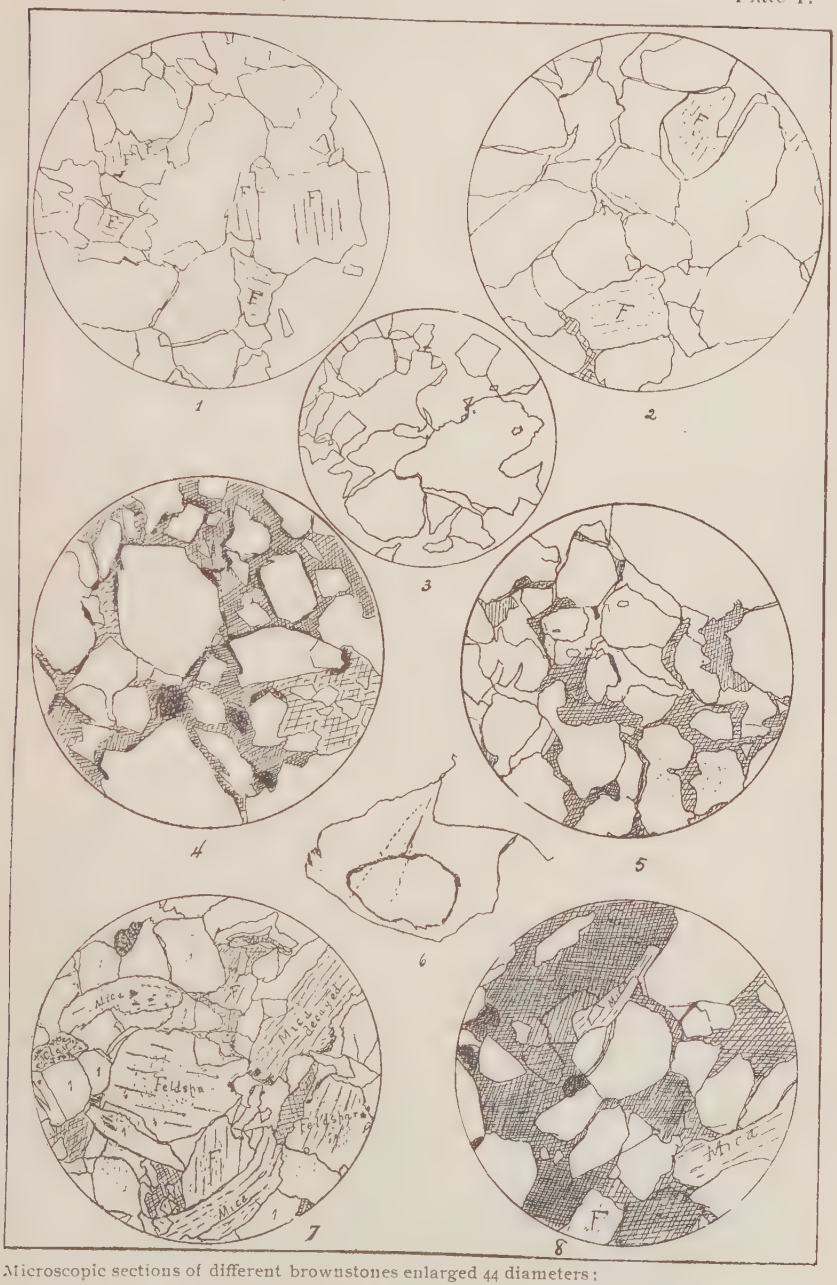
frost. On the other hand, they are less liable to be laminated or reedy, less liable to have clay seams, and will generally work more freely in all directions and are also less liable to be cut up by numerous seams, both vertical and horizontal, than the fine-grained ones. The fine-grained stones are generally stronger, but less elastic, not so apt to disintegrate, but more apt to crack or shell. They are equally well adapted to rock-faced, tool-dressed, or fine carved work.

The coarse conglomerate is abundant in several places over the brownstone area, but so far as observed by the writer, none of it in which the pebbles are the size of hickory nuts or larger has any value for building stone, as the cement is not strong enough to hold the hard pebbles in place. A conglomerate from this formation is quarried at the Point of Rocks, Maryland, in which the large pebbles are limestone, and it is known in the market as Potomac or calico marble. A stone somewhat similar in character to the Potomac marble is said to have been quarried at one time in Lancaster county, Pa., but the pebbles would drop out of the mass, and its use was abandoned. The upper part of plate 18 shows a view of one of the coarsest conglomerates in the State.

The microscope reveals several features in regard to the texture and composition of the rocks that are not brought out in any other way. It reveals both the mineral constituents and their condition of preservation, the proportions, kind and character of the cement. Some of these features are illustrated on the accompanying drawings* of typical sections of several varieties of rocks (Plate 1). Numbers 1 and 2 it will be noticed resemble each other somewhat and are strikingly different from the others. They each represent a very hard quartzitic sandstone with considerable feldspar among the grains, particularly No. 1, and having very little clay cement, nearly all the cement being crystalline quartz deposited in the interstices locking the grains into a very firm mass. The grains are all white, gray or colorless. No. 2 however in the rock mass is red or red-brown, which is produced by an exceedingly thin pellicle of red iron oxide partially surrounding many of the grains and small segregations in some of the more decayed feldspar and clay particles not shown on the drawing. It must be kept in mind that each of the drawings represents an area of the rock not much larger that the head of a pin, that is one forty-fourth of the diameter of the figure. No. 3 is an enlarged view of a more fine-grained portion of No. 2, which is entirely quartz, the secondary quartz binding the original grains in a mass. Nos. 4 and 5 are fairly representative samples of the Hummelstown stone (See also plate 10) composed of angular and subangular quartz in a cement of clay and

*Drawn with camera lucida, enlarged 88 diameters and reduced one half.

Brownstones of Pennsylvania. Plate I.



Microscopic sections of different brownstones enlarged 44 diameters:

No. 1—Lumberville feldspathic sandstone—feldspar and quartz and quartz cement.

2—White Haven red stone, some feldspar, mostly quartz and quartz cement.

3—An enlarged granule from No. 2 showing its quartzitic character in spots.

4 and 5—Typical sections of the Hummelstown brownstone.

6—Enlarged view of single grain of the Hummelstown stone showing secondary quartzose character.

7 and 8—Sections of a well known New England sandstone showing its micaceous character.

F signifies feldspar; cross-lined areas aggregates of clay, fine quartz, and iron oxide; very dark shading iron oxide; colorless areas quartz.

iron oxide. No. 5 is an area above the average in the relative proportion of quartz to the mass. No. 4 shows about the average percentage of quartz but the grains are more angular than the average; in some of the grains parts of the crystal faces may be seen. The freestone character of the rock is brought out fairly well, showing its adaptability to carving. It will be noticed that there is no parallelism about the grains and a line of fracture would run equally well in any direction. No. 6 is an enlarged view of a single grain from another portion of No. 5 showing its quartzitic character or origin. The original grain is shown near the middle of the figure, surrounded by the quartz subsequently deposited. All this took place before it became part of the Hummelstown stone, and the inner grain has been part of no less than three rocks of different ages, and the entire grain has formed part of at least two.

Nos. 7 and 8 are of a well known New England brownstone and given by way of contrast; No. 7 is a little above the average in the percentage of mica in the sample, and No. 8 a little above the average in the proportion of cement. Here one may read one of the causes of the scaling fronts of our eastern cities. Mica flakes or scales easily enough when fresh, but much more so when partially disintegrated and the fact that so many flakes lie in parallel directions is a great source of failure in the rock. Very little mica was observed in any of the Pennsylvania quarries.

The microscopic features of the different varieties are given elsewhere in this report with the description of the stone to which they refer.

Varieties of Pennsylvania' Brownstones:—There is probably a greater variety of brownstone in the State of Pennsylvania than in any other state in the Union. Only the general properties of the more common types are mentioned here and the different varieties are described more in detail in subsequent chapters.

In the New Red formation there are many varieties, the best known being the red-brown and the purple-brown Hummelstown stone, a fine grained stone, homogeneous in color and texture. The red-brown is a brighter color than the more eastern stone and the purple a richer color, both varieties being possibly a little harder than the eastern stone. They are said to work easily and are quite durable, standing the northern climate remarkably well and standing abrasion in steps or walks better than the average brownstone. It contains proportionately more quartz and less feldspar and mica than much of the eastern stone; in fact it is almost free from mica, the most injurious of the minerals.

The Cornwall, Mt. Gretna, and Schaefferstown stone is in general coarse-grained, contains many pebbles, has a light, warm, rich red

color varying from the light to a deep red in different localities. It has been obtained in limited quantities free from pebbles and makes a very handsome stone.

The Mohnsville stone is dark-colored, as dark as the eastern brownstone and contains many pebbles. It is associated with large beds of conglomerate. There are three varieties at Birdsboro and vicinity: a red shale, red-brown pebbly stone, and a light pink stone.

The Valley Forge, Port Kennedy stone is dark colored, coarse grained, and pebbly. At Norristown there is both gray and light brown stone irregularly bedded, mostly in small irregular pieces. The Fort Washington, Grenoble stone is light brown to gray and soft like the Norristown stone, containing many irregular seams, a nice building stone but not obtainable in large dimensions. The Frog Hollow stone is dark colored and hard, a strong durable stone regularly bedded. Newtown and Yardley stones are light brown colored with a faint purple tint and soft, occurring in regular beds with seams regular and even, furnishing dimension stone of good quality and pleasing color. The Lumberville stone is very hard, mostly light gray, but mixed gray and brown. The red stone of the Mauch Chunk formation at White Haven, Laurel Run, and Mocanaqua is very hard and generally uniform in color and texture. It, like the Lumberville stone, is intermediate in character between sandstone and quartzite. The "Brown granite" from Rockwood, Somerset county, resembles the White Haven stone. There is likewise a brownstone quarried at Ellwood City of which we have no data. There are both red and brown sandstones in the Medina, Clinton, and Catskill formations in different parts of the State, that so far as known have not been used for building and lack of time prevented a personal examination of the areas.

Durability of Pennsylvania Brownstones.—Much criticism has been raised in regard to the durability of the brownstones particularly in the cities. In New York and Philadelphia abundant evidence of its decay may be found in many of the brownstone fronts, conspicuously so in the ground courses and in small railings and columns of the steps and porches, yet in many places the plain surface of the walls is crumbling and scaling in a lamentable manner particularly along the base-courses. It is said to be customary with some residents in New York to have the faces of their brownstone fronts rubbed with stiff wire brushes every four years, to remove the disintegrated material and keep the wall clean, and sometimes where the stone is much decayed the stone-cutter cuts away the loose material, thus giving the stone a fresh appearance without removing it from the wall, and in some instances it has been found necessary to replace the stone by a new one. I am informed that the replacing of disintegrating stones in the wall by new ones

is a much more common practice in England than in this country, as the rocks seem to crumble more rapidly in that country.

The brownstone quarrymen claim that this disintegration of the rock is due to the fact that the stone has been wrongly laid in the wall, the claim being that the disintegrating stones are set on the edge and that if they had been laid on their natural bed they would have remained firm. This, however, is only one of a number of causes for the crumbling of the stone. While it may be and very probably is one of the most important factors in many cases there are other causes not to be ignored. They may all be enumerated as follows:

Causes of decay in the brownstones in the cities.

1. Setting the stone on edge. It should always be placed on its natural bed.

2. Quarrying in freezing weather or so late in the season that it could not be thoroughly dried (seasoned) before freezing.

3. Subjecting the stone to heavy blasting or to the blows of a heavy hammer in quarrying and dressing.

4. Carelessness in selecting the stone.

Where these precautions have been observed in selecting, working and using the stone (sometimes it is true accidentally, sometimes by intent,) it has been found to stand the test of time with a high degree of satisfaction. Tombstones in the cemetery at Middletown and Portland, Conn., have been standing there for two hundred years or more without a flaw. The same is true of some in the Trinity Church yard in New York city, and in the vicinity of Hummelstown, Pa., are stones more than 100 years old. The same is apparently true of the buildings since many of them as sound as when first erected, appear to be as old as others near by that are very much disfigured. These facts plainly show that the cause of decay is not necessarily inherent in the stone itself but due at least in large measure to mistakes in selecting and handling the stone. So important is this that it may be well to enlarge on some of the abuses above mentioned showing how they affect the life of the stone.

1. Setting the stone on edge — Nearly if not all sedimentary rocks have a grain and cleavage, most frequently seams of more or less prominence, commonly known as the bed or bedding of the rock. These were practically horizontal in the material as originally deposited or parallel with the surface of the water in which the material is deposited, except where the stone is cross-bedded, but where the rocks have been crushed, folded, or disturbed, the original horizontal position of the bedding may be changed to almost any angle with the horizontal, yet the occurrence of the seams or the grain or "reed" of the rock in most instances shows to the quarrymen the original bed of the rock.

Brick House, Wallenville, Pa., built in 1800, indicating the durability of the Brownstone limestone.

The particles composing the rock as they are deposited in the water are mostly dropped on the flat or long side, overlapping each other in a rough way and being rudely bound together in every direction but the vertical one. Pressure from overlying material tends to intensify this character. As the rate of deposition is not uniform for a great length of time there will be changes in the texture between the different layers of deposit which are frequently differently indurated. A period of slow or no deposition permits a hardening of the surface causing a parting between the indurated material below and the sediment next deposited. The prominence of this lamination, commonly known as bedding, depends on the character and on the induration of this material, sometimes being an open bedding plane and sometimes incipient, showing only after long exposure to the weather. As the rate of deposition is never constant there is an indefinite number of these planes, some showing in the fresh rock, some after short exposure and some only after long years of exposure to the weather. There is probably no stratified rock that is wholly free from these partings, many that appear to be massive and free from these seams when fresh showing the seams often in great numbers after exposure in the wall. These horizontal seams besides being lines of weakness are water lines, the water permeating in this direction much more readily than across these planes, and when the stone is put in the wall on edge the water collects along the lamination planes and freezes, the ice crystals acting as wedges to split off the flakes of stone. If the stone were laid on its natural bed the water would not so readily penetrate the rock and if it should, the pressure from the overlying rock in the wall would prevent scaling, and even though flakes were loosened they would be imprisoned so that they could not escape if good mortar were used.

The fact that the stone does yield or split so readily in this direction is the principal reason that so much of it is set on edge as it can be faced so much more quickly and easily, as many of the brownstone fronts consist simply of a thin veneering of brown stone backed up with brick or frame work. The temptation to set the stone on edge is greater in this case than where it is used in heavy masonry. Most of the stone-cutters know full well the greater strength and durability of the stone on its natural bed and they also know how much more readily and cheaply they can split off the slabs and set them on edge in the wall than they can dress the faces across the edge. Hence, it is the element of cheapness that causes this abuse of the brownstone. This evil is more pronounced where the stone is dressed by hand. Where it is cut and dressed by machinery it is more likely to be properly placed as it can be

sawed or planed about as readily on the edge as on the bed and the dealer will put the stone the way his conscience tells him is the right way for the future reputation of the stone. It is customary in some places, and should be in all places, to specify in the contract that the stone is to be cut to lie on its natural bed.

2.—Every rock when first quarried contains a certain percentage of water known as the quarry water or sap that when once dried out is not re-absorbed. The quantity of this varies in different rocks, but as a general rule the more porous the rock the greater quantity of this water. Sandstones being the more porous of building stones have as a rule a larger percentage of sap than any other class of building stones. If the freshly quarried rock is exposed to freezing temperature before drying the freezing of the water will injure the rock, sometimes by bursting off small scales or flakes, sometimes even bursting the rock into several pieces; frequently the injury is not perceptible at once, as the minute cracks formed may not show for some time but greatly weaken the stone so that it will succumb to subsequent frosts or strains more readily. Some sandstone companies will not guarantee any stone that is quarried after November first, yet in the great hurry to fill contracts builders take the risk and rush the stone into the building at all seasons of the year. This was conspicuously the case a few years ago when brownstone was the craze and the quarries were overcrowded with orders, and there is without doubt a considerable percentage of the disintegration of the brownstone in our northern cities due to this cause.

The stone is all the better for being quarried at least one or two seasons before it is put in the wall and should be quarried early in the season so that it can be thoroughly dried before winter. It is customary now for many of the larger dealers, and should be with all to keep sufficient stock on hand to fill winter orders without quarrying fresh stone.

3.—More stone is injured by blasting and hammering than is ordinarily acknowledged by the quarrymen. Before the days of the stone channeler and the Knox blasting system the injury was much greater than at present, and no doubt much of that in the old brownstone buildings of New York and Philadelphia was quarried with the free use of powder. Where a heavy charge of powder is used to loosen a large quantity of the stone at one time the heavy jar shatters the stone causing many incipient cracks which frequently appear only after long exposure to the weather.

It was formerly customary in the Portland, Conn., quarries to put in very heavy blasts, by drilling holes 6 or 8 inches in diameter and putting in 2 or 3 kegs of powder, which would loosen, and at the same time shatter a great deal of the stone. While this process has not been followed for ten or twelve years in those quarries, much

1. Pennsylvania Railroad bridge at Middletown, Pa., of Hummelstown brownstone.

2. Bridge at Edison, Pa., built in 1800 of stone from the neighboring hills.

SHOWING DURABILITY OF PENNSYLVANIA BROWNSTONES IN BRIDGES.

of the stone now in use was quarried in this manner. I have heard quarrymen in this State speak boastingly of the large amount of stone they knocked loose with one blast, apparently not realizing the effect it would have on the stone.

The Knox system of blasting, by using light charges properly distributed is a great improvement over the old system and reduces the injury done to the stone but does not do away with it. A better method yet is to use the channeling machine but as it is a little more expensive the blasting will no doubt continue. Another injury done to the rock is breaking it with heavy hammers. A workman strikes repeatedly with a heavy hammer in one place or along a certain line sometimes for five or ten minutes, finally breaking the rock, but before doing so shattering it throughout, loosening the grains and cracking the cement, injuring the "life" of the stone. These minute fractures, like the powder cracks, are not noticed at the time, as the fresh stone as it goes into the wall seems perfectly sound but after exposure to the weather for a few years they begin to appear and the stone quickly cracks and crumbles to an alarming extent. This method of quarrying is all right for broken stone for macadam or lime burning, but it cannot be too strongly condemned for quarrying building stone.

4.—There is one other precaution too frequently overlooked and that is to throw out all the bad and inferior stone. There is some stone in all quarries, in some quarries a great deal of it, that is intrinsically bad containing streaks of shale or spots of clay or iron oxide, or an excess of mica, much of which it is true is rejected in the best quarries; yet frequently in the small quarries and occasionally in the large ones under stress of rapid shipment or to fill on order taken at a low bid imperfect stone is put in against the better judgment of the quarrymen.

While many of the brownstones are not ideal building stones from the standpoint of durability, if the stone is properly dressed and quarried, quarried at the proper season and carefully selected it will give as good satisfaction as probably almost any other stone in the market. It will be found on investigation that the scaling and the disintegration of the stone is due largely to one or more of the abuses above mentioned, all of which may be avoided with proper care. What has been said has special reference to the more eastern brownstones as they have been longer in use and more extensively used, hence are better known and more criticised, but it is applicable to all others as well.

Dr. Julien gives as the result of his extended observations on the building stones in New York City and suburbs the following as the life of brownstones: Coarse brownstone, 5-15 years. Laminated fine brownstone, 20-50 years. Compact fine brownstone, 100-200 years

In another place he says in regard to brownstone that it seems to be a common, if not universal opinion (in his own opinion too hasty), that the days of the brownstone fronts for the better class of houses are probably numbered. It is the widely quoted opinion of one architect that it is of no more use for architectural work than so much ginger-bread; that the majority of the brownstone fronts will in 60 or 80 years be in ruins and the remainder much dilapidated.

That this was not and is not the universal opinion is shown by the continued use of brownstone. And it must still be borne in mind that there are good, bad and indifferent brownstones used with varying degrees of intelligence and lack of intelligence.

The qualities affecting the durability of the different brownstones of the State are discussed under the different varieties, as they vary widely in composition and texture, hence in the elements of durability.

Physical Tests.

Specific gravity.—By the specific gravity of the stone we mean its relative weight compared with water. Since all are comparable with water they are comparable with each other. The results in as far as they are accurate and intelligible show both the density and actual weight of the stone and give a means of comparing the different stones. However, as the result obtained depends largely on the method employed one is liable to grave errors in making comparisons if he does not know the method used in each case and the care used in making the test. For that reason we give the particulars in regard to the methods used in the following tables:

1.—The method used at State College was the specific gravity bottle, in which a small bottle, (.5 c. c.), is weighed (1), then filled with distilled water and weighed again (2). The bottle is then emptied, dried, the powdered stone put in and reweighed (3). These weights give the weight of the stone and the weight of the bottle full of water. The bottle containing the sample is partly filled with water and suction applied to exhaust the air bubbles and the filling completed and another weight taken (4). The specific gravity is then computed from the formula $\frac{3-1}{(2-1)-(4-3)}$. That is, the weight of the stone divided by the weight of the water displaced by the stone.

2.—General Gillmore's method* is to weigh the specimen in air, (A) then immerse it in water until bubbling ceases, and weighing (B) then removing it from the water and drying the surface in blotting paper and weighing again (C). The specific gravity is then found by dividing the weight of the dry stone by the weight of the saturated stone in air less its weight in water, the formula being $\frac{A}{C-B}$ specific gravity.

*Appendix II. Annual Report of Chief of Engineers for 1875. page 7.

3.—The method employed at the Rose Polytechic Institute, which is quite a common method for ordinary purposes, is to weigh the stone first in air, (A) and then in water as quickly as possible, (B) the specific gravity being the weight in air divided by the difference between the weight in air and the weight in water, $\frac{A}{A - B}$.

4.—The tests at Cornell University were made by weighing in air and in water and dividing by the loss of weight in water. But no particulars are given as to length of time the specimen was left in the water or the size of the pieces. Some were made by the Jolly balance and some by a chemical balance. The result is an average of 24 samples which vary between 2.586 and 2.722, a difference of nearly 9 pounds on the cubic foot.

The different processes enumerated will give different results. The first two aim to give the specific gravity of the particles or constituents of the stone exclusive of the air inclosed in the pores. They can only approximate that result as all the included air cannot be expelled. The third process aims to give the actual weight of the stone as it goes into the wall including the air in the pores. This can only approximate such a result as it is impossible to prevent the absorption of some water in the pores, the amount varying with the skill and speed of the operator. Hence the results, within the degree of accuracy attained, lie between the two extremes of the weight of the particles of stone exclusive of the air contained and the stone with all the included air.

A few comparative tests were made at State College to find the ratio between the results obtained by their method and those obtained by other methods, two on the Connecticut stones and one on the Laurel Run red stone. It will be noticed that there is a marked difference in the Connecticut stone and but little in the Laurel Run red stone, which may be accounted for by the fact that the latter is a dense stone practically almost free from pores, while the others are porous. However, not a sufficient number of duplicate tests were made to give the results the value they should have, as it was not known with what care nor with how many duplicates the tests were made at Watertown.

Comparative tests made on oolitic limestone from two localities by the first and third methods given above show 2.65 and 2.65 by the first and 2.48 and 2.46 by the third method, a very perceptible difference.

Greater care is necessary in making comparisons between porous stones than between the hard and dense ones. Thus the Hummelstown and the Connecticut stones by different methods show a difference of .3 equal to nearly 19 pounds on the foot, while tested by the same method the difference is only .02, a little more than one pound. As a rule those specimens having a low specific gravity have a high absorption.

The weight per cubic foot where not otherwise specified was obtained by multiplying the specific gravity by 62 1-2 the weight of a cubic foot of water.

Absorption tests.— The value of the absorption tests is in showing the porosity of the stone. Other things being equal the more porous the stone the greater the danger from frost. That is of two stones similar in all other respects but porosity the more porous one is liable to crumble first. Like all other tests, however, it is valuable only when taken with the other properties of the stone, as in many probably in most cases other properties are not equal, and it is not always safe to say that one stone is not so durable as another because it is more porous. It is to be regretted that more tests of this character are not available for comparison. All that could be obtained are given in the following table. The absorption of the Laurel Run stone as may be seen is remarkably low, while that of the Hummelstown stone is below the average for sandstone. In the list of building stones published by Gilmore the specimens of sandstones from different regions range from 1 in 15 to 1 in 70, with most of them below 1 in 30 and a great many below 1 in 20.

Crushing tests of Brownstone.— On the accompanying tables all the reliable crushing tests that could be obtained on the brownstones of Pennsylvania are given, along with the tests on brownstones from other localities for comparison. The authority is given in each case.

The White Haven stone, the Laurel Run stone, and the Lumberville stone run far above any of the sandstones in crushing strength as might be expected from their quartzite character. There are few quartzites with which to compare them. The Potsdam stone (No. 19) is quartzitic but the result is so abnormally large as to be useless for comparison. The only other quartzite in the market among building stones known to the writer is the Sioux Falls stone, no tests of which are at hand. The Medina sandstone of New York is very hard and possibly more or less quartzitic.

The crushing strength of the true sandstone as shown on the accompanying list and other lists, ranges from 3,000 to 12,000 pounds per square inch, only two on the list outside of the Hummelstown stone ranging as high as 13,000 pounds. One of these is the Medina stone which may be quartzitic, and one from Cromwell, Conn. The Hummelstown stone is above the average brownstone in crushing strength as is the Birdsboro stone, both of which are as hard as is consistent with ease of working. The Birdsboro stone in crushing gave way all at once and quietly, while the Hummelstown stone gave way with a loud report, all of the specimens giving a good pyramid at the top and some a pyramid at the base, but the latter was generally shattered in the explosion.

There is a false impression among stone dealers and others in regard to the signification of the crushing test. The desire seems to be almost universal to have a crushing test as high as possible. Objection was raised by one company to the publication of some results because they thought they were not high enough. A high crushing test signifies in general a hard rock, but hardness is not the most desirable quality in a building stone, in fact it is not always a desirable one; on the contrary it may be an objection. With rare exception a stone that is hard to crush in the machine is correspondingly hard to crush, cut, carve or break under the stone cutter's tool.

The idea that high crushing strength shows great durability, while a common one among dealers, is a mistaken one. Hardness or great strength, while a frequent accompaniment of durable stone, is not always so, nor are all hard stones durable ones. After a careful study both in the field and in the laboratory, the writer is satisfied that one of the sandstones on the accompanying list among the very lowest in crushing strength is among the most durable ones.

There are some sandstones so soft when first quarried that they may be easily crushed in the hand in small pieces, but they will stand exposure where not subject to abrasion better than many of the hardest rocks.

Some of the useful things which crushing tests if properly made show are the uses for which the stone is fitted. Thus a stone with a crushing strength of less than 6,000 pounds per square inch is not suitable for paving blocks, sidewalks, steps, or any place where it will be subject to wear. On the other hand it may be easily cut and carved and for most building purposes it may be one of the best and most durable stones. Again a stone with a crushing strength of more than 14,000 or 15,000 pounds per square inch is too hard for easy cutting or dressing and is not suitable for carved work but might make good paving material or rock face work. Uniformity in the results indicates homogeneity in the stone, a useful and important property. A great difference between samples tested on the bed and those on edge indicates a degree of lamination which renders it unfit for carved work or projections. A similarity of results between tests on the bed and on the edge show a freestone character. A low crushing strength for an apparently hard stone indicates inherent weakness, probably in the shape of weather, powder,—or hammer-cracks, or clay secretions.

In comparing the results on the accompanying list or on any other list it is advisable to keep in mind that strength per square inch does not vary directly with the difference in area. That is a cube 2 inches on each side is more than four times as strong as a one-inch

Table showing crushing strength, specific gravity, and ratio of absorption of brownstones.

No.	Quarry.	Locality.	Crushing strength per square inch.	No. specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority, or the place where tested
1	George Brook's,	Birdsboro, Pa.,	11,448	3				State College, Pa., 1897.
2	Hummelstown Brownstone,	Waltonville, Pa.,	14,753	3				Watertown Arsenal, 1897.
3	[illegible]	Waltonville, Pa.	11,666	3				Rose Polytechnic Institute, 1[illegible].
4	[illegible]	Waltonville, Pa.,	12,730	3				Richle Bros., 1897.
5	[illegible]	Waltonville, Pa.	13,190	2				Richle Bros., 1899.
..	Hummelstown Brownstone,		12,710		(1)2.55	146.6	1-27	Merrill—Stones for Building and Decoration, p. 413.
..	Hummelstown Brownstone,	Waltonville, Pa.			2.66	166.1	1-87	State College, 1897.
6	Lumberville [illegible]	Lumberville, Pa.,	19,895	1			1-93	Fairbanks' laboratory, N. Y.
7	Lumberville quarries,	Lumberville, Pa.,	24,625	2	2.60	162.5	1-88	Booth, Garret & Blair, Philadelphia.
8	Lumberville [illegible]	Lumberville, Pa.	22,625	2				Carlson & Olsen.
9	Oliver's quarries,	Laurel Run, Pa.,	22,500		2.66			Columbia College School of Mines.
10	Oliver's quarries,	Laurel Run, Pa.,	17,600	12	2.66	166.0	1-900	Cornell University.
11	Oliver's quarries,	Laurel Run, Pa.,	23,600	1	2.66	166.0		Cornell University.
12	Jno. Danek[illegible]	White Haven, Pa.	22,252	2				Watertown Arsenal
13	Jno. Danekel's quarry,	White Haven, Pa.,	22,750	1				Watertown Arsenal
13	Portland quarries,	Portland, Conn.,	12,580	6	2.35 (2)2.63	146.9	1-40	Watertown Arsenal.
14	Portland,	Middletown, Ct.,	6,250	2	2.36 (2)2.68	148.5	1-40	Gen. Gillmore, Chief of Engrs.
15	New England Brownstone Company,	Cromwell, Ct.,	16,894	2	2.50	156.0	1-40	Watertown Arsenal.
16	James & Marra, red,	E. Longmeadow, Mass.,	12,210	....	2.49	154.5	1-23	Watertown Arsenal, Dec. 1883.
17	James & Marra, brown,	E. Longmeadow, Mass.,	12,330	....	2.48	154.5	.....	Watertown Arsenal, Dec. 1883.
18	Worcester quarry, brown,	E. Longmeadow, Mass.,	10,936	2	2.49	155.3	1-19	Watertown Arsenal, December, 1883, 6-inch cube.
19	Maynard quarry, red,	E. Longmeadow, Mass.,	10,274	1	2.49	155.3	1-20	Watertown Arsenal, March, 1889, 6-inch cube.
20	[illegible]	Medina, N. Y.	16,921	2	2.40	150.0	1-52	Gen. Gillmore, 1875.
21	[illegible]	Little Falls, N. J.,	9,500	2	2.25	140.6	1-34	Gen. Gillmore, 1875.
22	[illegible]	Potsdam, N. Y.,	42,800	1	2.60	162.3	1-48	School of Mines, Columbia College.
23	J. B. Lyne & Sons,	St. Anthony, Ind.,	3,000	....	.....	.....	1-13	Rose Polytech. Inst., Terre Haute, Ind.
24	[illegible]	Marquette, Mich.,	7,750	..			1-70	Stone, June, 1894.
25	[illegible]	Marquette, Mich.,	5,992	3	2.29	142.8	1-22	Gen. Gillmore.
26	[illegible]	Marquette, Mich.,	6,150	6	2.16	135.3	1-20	Gen. Gillmore.
27	[illegible]	Marquette, Mich.	7,856					Geol. Survey of Mich., 1891-92.
28	[illegible]	Portage Entry, Mich.,	5,400		[illegible]	[illegible]	1-11	Stone, June, 1894.
29	[illegible]	Portage Entry, Mich.,	6,350	....	.....	.....	.....	Geol. Surv. of Mich., 1891-92.
30	[illegible]	L'Anse, Mich.,	10,645	....	.....	.....	.....	

31		Keweenaw Bay, Mich.									
32		Bass Island, Wis.									Stone Line, 1891.
33		Fond du Lac, Wis.									Gen. Gillmore.
34		Houghton, Wis.,									Gen. Gillmore.
35		Wilson Island,									Columbia College, School of Mines.
36	Minnesota Sandstone Company,	Fond du Lac, Minn.,									
37		Kettle River, Minn.,									The Geo. of Mine [illegible] 298.
		Edinburgh, Scotland									[illegible] Brown Arsenal

(1) A. Julien—Decay of Building Stones of N. Y. city

(2) Made in Chem. Lab. Penna. State College

cube, or stronger than four one-inch cubes placed side by side. Gillmore has computed the increase from a series of experiments on different sized blocks to be in proportion to the cube roots of the sides, thus giving a decided increase in result for the large specimens over the smaller. That is, a sample of a stone tested in a 4-inch cube would give double the strength per square inch that a sample 1-2-inch cube would give. But the desire to get as large results as possible induce both the dealers and the ones making the test to take as large a specimen as possible and divide the total stress by the area of crushing surface. On the accompanying table while most of the specimens were 2-inch cubes some were larger, but as the sizes of a number of the specimens could not be obtained none of them are given. Also tests made at different places by different operators on the same stone will give different results. So that comparisons should not be too rigid until the different conditions are considered.

Fire tests. — Tests were made in the assay laboratory at State College on samples of sandstone from different localities in the State to show its fire-resisting properties. There were samples from Hummelstown quarries, from the Middletown and Hummelstown quarry, from Birdsboro, Mohnsville, Grenoble, White Haven and Laurel Run. Along with these for comparison were specimens of the Potsdam sandstone, New York, the green serpentine from Thornbury and the oolitic limestone from Indiana.

The specimens were first heated in the oven until zinc melted on their upper surface, about 777° F., and some were cooled in air and some in cold water, all of the specimens being uninjured.

They were then heated until aluminum melted on the upper surface, about 1,157° F., but, the oven being much hotter at one end than the other, some were at a higher temperature. The limestones showed traces of calcination by a thin coating of lime in spots over the surface. The sandstone from the Middletown and Hummelstown quarry was perceptibly softer and brighter colored. The Hummelstown and the Mohnsville stones were brighter colored, but the texture and strength seemed unchanged.

The specimens were then heated until sodium chloride melted on their upper surface, nearly 1600° F., while many of them were exposed to a higher temperature, a bright red heat. The limestone was calcined to quicklime; the serpentine had lost its green color and cracked in several places; the Middletown and Hummelstown stone was a light red color and quite soft and friable. The Hummelstown stone was a brighter red, but was not cracked even with cold water, and apparently nearly if not quite as strong as before heating. The Mohnsville had changed its dark brown color to a bright red brown. The Birdsboro pink sandstone and the Grenoble

stone showed no effect of the heat in any way. The White Haven and Laurel Run red stone changed color to a darker brown and duller color, but the texture was uninjured.

The tests were not carried further, but this is sufficient to show that these sandstones, which are fairly representative specimens, are excellent fire-resisting stones. No tests were made on the more aluminous stones of the Delaware valley. The stones tested, while possibly not absolutely fire-proof, are more nearly so than a great many stones in the market. In few ordinary fires will the stone be subject to a temperature higher than 1600° F., which the different stones stood without injury except in the color of some specimens.

Occurrence of brownstones in Pennsylvania.—The brownstones, so far as commercially developed, are confined largely to the eastern and southeastern part of the State. The New Red area, in which most of the quarries are located, as shown on the accompanying map, extends from the Delaware river north of Trenton in an irregular rather broad belt west-southwest through Bucks, Montgomery, Berks, Chester, Lebanon, Lancaster, Dauphin, York and Adams counties. The most productive quarries are those near Hummelstown. Other less productive quarries are at Mt. Gretna, Schaefferstown, Mohnsville, Birdsboro, Phoenixville, Valley Forge, Port Kennedy, Fort Washington, Norristown, Grenoble Station, Neshaminy, Newtown, Yardley and Lumberville. Quarries of considerable size near Middletown and Goldsboro were once productive, but are now abandoned. There is a sample in the World's Fair collection from Adamstown, Lancaster county, but it is not known whether the quarry is in operation now or not.

The Mauch Chunk formation, from which red-brown quartzose sandstone is obtained, surrounds the anthracite coal basins in the eastern part of the State, and, according to the State geological map, underlies the coal measures of the west and west central portion of the State. So far as is known to the writer, the only places that the Mauch Chunk red stone has been quarried are the southern part of the north anthracite field and the east end of the middle field at Mocanaqua, Laurel Run and White Haven. A brownstone has been quarried near Rockwood, Somerset county, that may be from this formation, but no definite information is at hand concerning it. A brownstone used for building purposes is quarried at Ellwood City, in the west part of the State, but to what extent is not known. It is presumably of Carboniferous age, but no particulars in regard to the quarry are at hand.

There is brownstone in the Catskill, Clinton and Medina groups in Pennsylvania, but so far as known no quarries have been opened in any of them. Time did not permit a personal examination of these areas, to see whether good stone occurred in commercial quantities or not. The fact that there are many productive quarries in

the Medina formation in Western New York and the promising appearance of the few outcrops observed in this State would suggest the possibilities of good brownstone from one or both of these formations. The following list contains all the brownstone quarries known to the writer in the State:

List of the brown and red stone quarries in Pennsylvania.

(Numbers correspond to numbers on the map).

Numbers 1-42 are in the New Red area.

1. Reehling quarry, 2½ miles west of Goldsboro—1851-'56, Thomas Symington; 1856, Geo. Betz, J. H. Killwell; 1869-'70, Frazer and Reehling; 1870-'80, C. F. Reehling. Now idle.

2. Middletown and Hummelstown quarry, a mile north of Middletown—Middletown and Hummelstown Co., now in the hands of a receiver.

3. Pennsylvania Brownstone Co.'s quarry, 2 miles south of Hummelstown—1886-1890. Idle since that time

4. Hummelstown Brown-Stone Co., Waltonville, 3 miles southeast of Hummelstown, 1800 to the present. 4 quarries —1800-1860, local; 1860-66, Henry Brown; 1866-1877, Pennsylvania Brown Freestone Co., 1877-'97, Hummelstown Brown-Stone Co.

5. Co-operative Brownstone Co.'s quarry, a half mile east of Waltonville, new small opening, now idle.

6. Stoverdale Brownstone Co's quarry, ½ mile south of Waltonville, 1895, now idle.

7. Hummell quarry, a mile south of Waltonville, now idle.

8. American Brownstone Co., 2 quarries, 1¼ miles south of Waltonville, 1890-1893.

9. Swatara quarry, a mile south of Hockersville, 1894-1895.

10. Derry quarry, 2 miles south of Hockersville—Francis, Painter & Co., 1884-1888.

11. Mount Gretna quarry—A. G. DeHuff.

12. Local quarries, south of Schaefferstown, operated by Joseph Watson and others, thirty years or more.

13. Thurber and Wiegel quarries, south of Kleinfeltersville.

14. John Westley's quarry, 2 miles southwest of Mohnsville—1886-'97.

15. Amos Price's quarry, 2 miles southwest of Mohnsville—1883-'97.

16. Daniel Shonour's quarry, 2½ miles southwest of Mohnsville—'97.

17. Brooks' quarry, 2 miles south of Birdsboro. Other smaller quarries in the vicinity. Idle.

18. Mount Clare quarry, on the hill above Mount Clare—'97.

19. Malin Miller's quarry, Phoenixville. Idle.

20. Newton Walker's quarry, ½ mile east of Perkiomen Junction. Idle.

21. Charles Johnson's quarry, a mile east of Valley Forge—1897.

22. Port Kennedy Stone Company, Betzwood, opposite Port Kennedy—'97.

23. Port Indian quarry, on the Pennsylvania Railroad near Port Indian. Idle.

24. Derr quarry, west side of Norristown. Other local quarries. Idle.

25. John Brown's quarry, ½ mile west of Bridgeport, Norristown—'97.

26. Schenlein quarry, ½ mile west of Bridgeport, Norristown—'97.

27. Tyson's quarry, ¼ mile west of Bridgeport, Norristown—'97.

28. Local quarry, east side of Norristown.

29. Kennedy's quarry, ½ mile north of Fort Washington—'97.

30. Wallace's quarry, ½ mile north of Fort Washington. Idle.

31. Frog Hollow quarry—Joseph Paul, 1876-'97; ½ mile south of Neshaminy post office.

32. Loux quarry, A. P. Loux, Tradesville, 2 miles southwest of Doylestown—'97.

32a. Grenoble quarry, Grenoble station—1891, by Jameson & Ryan; 1892-'93, J. J. Ryan; '95-'97, Moody and Edwards.

33. Mitchell quarry, Newtown—1868-9, S. Prior & Co.; 1869-'72, Prior & Son; 1882-'97, Henry Mitchell.

33a. Watson's quarry, Newtown—1894-'95, Chas. Watson. Idle.

34. Nicholson quarry, ½ mile west of Yardley—Operated for a number of years by Twining Bros.; later by James Shevlin; now idle.

35. Yardley quarry, ½ mile north of Yardley—1873-1882, by Henry Mitchell; 1888-'97, by James Shevlin.

36. White quarry, 2 miles north of Yardley—Wm. White—'97.

37. Local quarries, along the canal south of Yardley; now idle.

38. Carversville quarry, Carversville—1881-'85, by Twining Bros.

39. Conner's quarry, a mile south of Lumberton—1890-'97 Thos. J. Conner.

40. Sampsell quarries, a mile south of Lumberton—J. M. Sampsell.

41. Paxson's quarry, Lumberton—1880-'97, W. S. Paxson.

42. Quarries of the Lumberville Granite Co., Lumberton, a mile below Lumberville—'97.

The following are in the Mauch Chunk Red Stone:

43. Reiser and Doland quarry, west bank of the Lehigh river, 3 miles below White Haven, near Drifton Junction—1894-97, by Reiser and Doland, Wilkesbarre.

44. Cooper Bros.'s quarry, west bank of the Lehigh river, 2 miles below White Haven—Cooper Bros., 1892-'97.

45. John Redington & Co.'s quarry, east side of the Lehigh river, 1 mile below White Haven—'97.

46. Fox quarry, on the west side of the Lehigh river, opposite No. 45. Idle.

47. Daneker's 3 quarries, west side of the Lehigh river, 2 miles above White Haven—1873-1897, by John Daneker.

48. Schmitt's quarries, Laurel Run, 3 miles south of Wilkesbarre—'97. Other quarries adjoining not in operation.

49. Elbow quarry; several small quarries at and near the Elbow on the Central Railway of New Jersey, 2 miles south of Wilkesbarre; only one in operation at present.

50. Mocanaqua quarry, a half mile above (N. E. of) Mocanaqua; idle.

The following quarries are not shown on the map.

51. Somerset Brownstone quarry, near Rockwood, Somerset Co.—Operated by J. C. McSpadden.

52. Ellwood City quarry—Operated by Wilson Bros. & Co., Ellwood City, Lawrence County.

Methods of quarrying and handling the brownstones.—In all of the small quarries throughout the State the work is mostly done by hand, and frequently with liberal (entirely too liberal) use of powder. Holes are drilled by hand either with the churn drill or jumper, and heavily charged with powder and fired, loosening sometimes a large quantity of stone. If the loosened blocks are too large to be broken by repeated blows with a heavy hammer, another charge of powder is put in and the demolition completed.

As may be well imagined, but little good dimension stone is quarried in this manner. Yet much stone that would be good dimension stone if properly quarried is taken out in this way. Where good dimension stone is required it is taken out by splitting the blocks from the ledge with wedges (plugs and feathers), or by the Knox blasting system, or some similar system. Channeling machines are not used in any of the brownstone quarries of the State. Nor is the stone in any of them in such shape as to require or justify their use. There are numerous seams in all of the quarries, either bedding or joint seams, and by utilizing these seams the stone can be extracted more cheaply by wedging and blasting than by channeling. In the larger quarries the Knox system of blasting is used, which, if properly managed, reduces the injury to the stone almost to a minimum.

The Knox blasting system, which is patented, consists essentially of making a series of elongated holes along the line of desired fracture, putting in a light charge of powder, leaving an air chamber between the powder and the confining plug and firing all simul-

taneously with an electric battery. It requires a special reamer to make the drill hole oval or elongated, or the hole may be made by boring two holes side by side and breaking down the wall between them. The Githens system claims to be an improvement over the Knox system of having a drill that will make a hole of the required shapes in one operation. One advantage in this system of blasting is the great saving of stone, and another is the improved quality of the stone, as it is not subject to the jar of such a heavy blast. In the old system the hole was drilled and loaded with a heavy charge of powder that would generally loosen and greatly shatter the rock, but there was no means of directing the force so that very irregular blocks were produced, with a great waste of rock and time and energy in squaring them. In the new system the elongated holes direct the line of fracture with the greatest diameter of the hole, and the stone is broken into rectangular blocks, the regularity of which depends on the number of holes and the character of the rock. Some stone is much straighter in the grain than others, and requires fewer holes to make a straight break. Thus, the Lumberville stone is readily broken by holes two or three inches deep, while to make a break equally straight in the Yardley stone would require the holes to be drilled nearly through the block to be broken. The number and depth of the holes necessary for a straight break is learned by experience in the different quarries.

Where the rock occurs in regular layers, after once getting a straight face successive blocks are broken off by putting a row of holes parallel with the face and firing with a battery. The channeling machine may be used to advantage in cutting out the ends of the quarry, or if on a long face, making cross-cuts.

While there is no question that this method of quarrying is an improvement over the old method of blasting, it still does not do away entirely with the injury that comes from blasting the stone, and while in many instances it would be more expensive to remove the stone by channeling and wedging, the stone would be all the better for being so quarried.

In all small quarries the stone is loaded on the wagon, car or boat by hand, or with the use of a hand-power or horse-power derrick. The large quarries have steam hoists. The Hummelstown Brown Stone Co. has 36 derricks erected, besides two wire cable ways, and steam travelers at the mill. They have also a large steam shovel for handling the waste and a railway track through the yard and to all parts of the quarries. The only other brownstone quarries in the State that use steam power are those of the Lumberville Granite Co., at Lumberville; John Schmitt's quarries, at Laurel Run, and John Daneker's quarries, at White Haven. The first named has a wire cable with a carrier run by steam across the Delaware river to

deliver stone to the railway. The Middltown and Hummelstown quarry, near Middletown, is equipped with steam and electric plant, but it is now idle, and has been for several years.

Nearly all the quarries in operation are near the railway or the canal. The shipping facilities of each is mentioned in the description of the quarry.

Uses and adaptability. — Brownstones are used for almost all classes of work for which any other rock is used. It is pre-eminently a building stone, probably one of the most valuable in the market, and adapted to as many different classes of structural uses as any other. In Pennsylvania, besides its use as a building stone, it has been used as sand for plastering, masonry, and pig beds in the furnace, for furnace hearths, lining blast furnaces, monuments, paving blocks, curbing, flagging, stepping stones, macadam and concrete. But by far the larger part quarried goes into structures of some kind: The better qualities into superstructures as walls or trimmings and the inferior grade into foundations, bridge piers and abutments, culverts, retaining walls, etc. The different varieties are all adapted to these different uses if selected with care. Thus, where the stone is to be carved or smooth-dressed a fine grained stone of homogenous color and not too hard should be selected; for rock-faced work and heavy masonry the coarse-grained can be used; but all kinds are suitable that are sufficiently strong and durable; in bridge piers and foundations mixed stone, that is, stone variegated in color and texture, may be used. In nearly all quarries there is considerable stone that may be as strong and durable as any, but is lacking in beauty or homogeneity, and cannot be used as first-class stone in superstructures, but which can be used to advantage in bridge work, where strength and not beauty is required.

Soft stones like those from Newtown and Yardley are admirably adapted for building in face work or for heavy trimmings, but will not stand the wear in pavements and streets, or heavy cross-strain in lintels and sills, unless protected in some way. Stones like those from White Haven, Wilkesbarre and Lumberville are sufficiently hard not only for foot wear in pavements, but for street wear as Belgian blocks or crushed stone. On the other hand, they are not adapted to buildings where much cutting or carving is to be done on account of their hardness. A stone with weak transverse strength should not be used for lintels, sills, caps, etc., where it is subject to strain unless well protected by over-arching or by other means. It is not advisable to put a soft or porous stone in the foundation or base-course if it can be avoided. The most trying place for a stone in the entire building is in the part next to the ground, where the moisture absorbed from the earth is repeatedly frozen. This part of the building should have the most compact and least absorbent stone, and should be laid with the best cement.

SHOWING THE USE OF PENNSYLVANIA BROWNSTONES IN CHURCHES.

Lutheran Church, Hummelstown, Pa.
Hummelstown brownstone.

St. Nicholas German Catholic Church, Wilkesbarre, Pa. Laurel Run red stone.

Presbyterian Church, Bloomsburg, Pa.
Hummelstown brownstone.

To obtain the best architectural effects care must be taken in selecting the colors. This is largely in the hands of the architects and the contractors, but when they persist in putting up entire blocks of dark brownstones along narrow streets, it is time that owners and residents should protest. Some shades of brownstones are pretty in themselves, others have their natural beauty intensified and brought out by judicious mingling with other colors and shades.

The lighter colored brownstones could be used in larger quantities, either in the same building or the same town, with more pleasing results than the dark colored, but the two together will produce a better effect than either alone. The darker stones are better adapted to business blocks on the principal thoroughfares, as they do not soil or show stain so readily. The lighter colored ones are adapted to residences in the suburbs or country towns.

The very hard quartzite varieties should not be used in excess in face work on large, unbroken surfaces, as the hard, stony glare produced by them is repellent. On a large face this could be relieved in part by an intermingling of sawed or tool-dressed faces among the rock-faced ones.

Plates 3, 4, 5, 6, 7, 9, 11, 12, 14, 15, 16, 17 and 19 show some of the architectural uses of Pennsylvania brownstones, and the following pages contain a list of many of the buildings constructed of the native brownstone. This will give an idea of the extent of the industry, the varied uses and adaptability of the stone. It will show that the usage is more than local. The primary object of the list, however, is to enable architects, builders and others to see where the stone has been used that they may judge by observation in regard to its beauty and adaptability, as a building shows much more than a hand sample. The attempt was made to have the list sufficiently extended and specific that persons in any part of the State, or the adjoining states, would know where to turn to buildings of Pennsylvania brownstone without travelling far. Where the part of the building in which the stone was used is not known a question mark is placed.

BUILDINGS CONSTRUCTED OF PENNSYLVANIA BROWNSTONE.

Giving the location of the building, the architect and the part of the building in which the stone is used, where known, and the quarries from which the stone was obtained. An ? signifies that the part of the building and the architect are not known to the writer.

PENNSYLVANIA.

Allentown:
High school, base, entrance and trimmings. H. B.-S. Co.*
Robert E. Wright's residence. ? Lumberville quarries.

Ambler:
Presbyterian church, entire. Fort Washington quarries.
Godfrey Hotel, entire. Fort Washington quarries.
Mrs. Reed's residence, entire. Fort Washington quarries.

* In this list H. B.-S. Co. signifies that the stone is from the quarries of the Hummelstown Brownstone Company.

Bethlehem:
Hon. John Fritz, residence, base, entrance, porches and trimmings. H. B.-S. Co.
Bloomsburg:
Columbia county court-house, base, entrance and trimmings. H. B.-S. Co.
Presbyterian church, entire, facings and trimmings. H. B.-S. Co.
Carlisle:
Denny Hall, Dickinson College, entire, facings and trimmings. H. B.-S. Co.
Bosler Hall, Dickinson College, base, first story, entrance porch and trimmings. H. B.-S. Co.
Jail. ? Goldsboro quarry.
Catasauqua:
High school base, entrance and trimmings. H. B.-S. Co.
Chaderocksville:
School house. ? White Haven quarries.
Cornwall:
Robt. Coleman's mansion and the North Cornwall railway station, numerous dwellings and office buildings about Cornwall, entirely from local quarries.
Danville:
Hospital for the Insane. ? Goldsboro quarry.
Opera-house. ? Goldsboro quarry.
Doylestown:
Court-house, facings. Lumberville quarries.
Court-house, trimmings. Yardley quarry.
Easton:
Presbyterian church. ? Yardley quarry.
Rosenbaugh, residence. ? Lumberville quarries.
Grant, residence. ? Lumberville quarries.
Eddington, Phil'a:
Industrial school. ? Newtown quarry.
Emporium:
Cameron county court-house, base, entrance and trimmings. H. B.-S. Co.
Fort Washington:
Lutheran church, J. M. Kennedy's residence and a number of other residences. From the Fort Washington quarries.
Gettysburg:
Pennsylvania College, base, doorway and trimmings. H. B.-S. Co.
Lutheran Theological Seminary, base, entrance, porch and trimmings. H. B.-S. Co.
Brua Memorial church, base, tower base, entrance and trimmings. H. B.-S. Co.
Hazleton:
High school building, base, entrance and trimmings. H. B.-S. Co.
Church Street school, base, entrance and trimmings. H. B.-S. Co.
Harrisburg:
Grand stairway, entrance to the State Capitol.
Westminster Presbyterian church, entire. C. W. Bolton, architect.
Pennsylvania Railroad Station, base and trimmings.
Administration building, State Insane Asylum, porch, columns, caps, entrance and trimmings.
High school building, the entrance and all the trimmings above the base.
Harrisburg Club the base, first story, entrances and trimmings.
Governor's Mansion, front. All the above from H. B.-S. Co.
State Arsenal, C. L. Bailey, and Rudolph Kelker's residences. From Goldsboro quarry.
Holmesburg, Phil'a:
St. Dominic church, doorways and trimmings. Newtown quarry. Steps and sills. H. B.-S. Co.
Hummelstown;
Lutheran church (J. A. Dempwolf, architect), entire, facings and trimmings. H. B.-S. Co.
Huntingdon:
Huntingdon Reformatory base entrances and trimmings of administration building, base, water-tables and trimmings of wards, base, water-tables and trimmings of walls. H. B.-S. Co.
Kingston:
Public school building, base, entrance and trimmings. H. B.-S. Co.
Music Hall. ? White Haven quarries.
Lancaster:
German Reformed Theological Seminary, base, doorways and trimmings. H. B.-S. Co.
People's Bank, entire front of dressed stone. H. B.-S. Co.

Lock Haven:
Central State Normal School, steps, water-table and all trimmings. H. B.-S. Co.
Mansfield:
Mansfield Normal School, base, water-table, main entrance and trimmings. H. B.-S. Co.
Mauch Chunk:
Carbon county court house, facings from the White Haven quarries. Doorways and trimmings H. B.-S. Co. (See Plate 5.)
Middletown:
Pennsylvania Railroad bridge, W. H. Brown, engineer. H. B.-S. Co.
Millersville:
Scientific building, State Normal School, entrance and trimmings. H. B.-S. Co.
Library building, State Normal School, entrance and trimmings. H. B.-S. Co.
Mount Holly:
Library, entire, facing and trimmings. H. B.-S. Co.
Newtown:
First National Bank, Presbyterian chapel, Methodist church, addition to the public school, residences of George Black, Samuel C. Case, Thos. Briggs, Mrs. John Copper, all built entirely of stone from the Newtown quarry.
Norristown:
Haws Avenue M. E. church, water-table, steps and trimmings. H. B.-S. Co.
One church, several residences and part of the high wall around the Catholic school, of stone from the local quarries.
Philadelphia:
Residence of Mr. Ellis, W. H. Decker, architect; entire front and approaches of dressed and carved stone.
Residence of Mr. Frazier, base and trimmings.
Residence of Mr. Drexel, base, entrance and trimmings.
Buildings of University of Pennsylvania, base, doorway and trimmings.
Medico-Chirurgical College, base, entrance and trimmings.
Hahnemann College, base, approaches and all trimmings.
St. Mathias church, facings and trimmings.
Holy Communion church, base and trimmings.
German Society building base, doorway and trimmings.
Young Maennerchor building, base, doorway and trimmings.
Philadelphia Bourse, approaches and base.
Bullitt building, G. W. and W. D. Hewitt, architects; doorways, entire first story and trimmings above.
Academy of Fine Arts, base, aproaches and other brownstone trimmings.
Academy of Natural Sciences, base and brownstone trimmings.
Frankford pumping station, Tacony, Philadelphia, base and trimmings.
Spring Garden pumping station, base and trimmings.
Philadelphia Library, trimmings.
Philadelphia and Reading Railway Station, Frankford, Philadelphia, base, entrance and trimmings. This and all the above of H. B.-S. Co.
Philadelphia Traction Company power house, Market street, foundation and trimming from Lumberville quarry.
German Hospital, Girard and Corinthian avenues; all face stone. Newtown quarry.
Episcopal Hospital, Front street and Lehigh avenue; face stone. Newtown quarry.
Methodist Hospital, Broad and Wolf streets. ? Newtown quarry.
Parochial school and parsonage for St. Anne's church, Lehigh avenue and Cedar street. ? Newtown quarry.
Convent of the Good Shepherd, Chew street, Germantown, Philadelphia. Newtown quarry.
Pottsville:
Garfield school, base, entrance and trimmings. H. B.-S. Co.
Public school building. ? Goldsboro quarry.
Tenth census, 1880, says the Goldsboro brownstone is used in two or three buildings, and that the Hummelstown brownstone is the stone chiefly used for trimmings, being in every way satisfactory.
Reading:
First Baptist church, trimmings, steps and approaches. H. B.-S. Co.
Home of the Good Shepherd, base, water-table, entrance and trimmings. H. B.-S. Co.
Court-house. ? Mohnsville quarry.
Keystone Bank, on Penn above Sixth. ? Mohnsville quarry.
Stevens building. ? Mohnsville quarry.

Reading—continued:
Residence of John Barby. ? Mohnsville quarry.
Several school houses. Mohnsville quarry.
Residence of J. H. Sternbergh, all face stone. Local quarries, pink stone, south of Birdsboro. (See Plate 19.)
Chapel and entrance buildings of the Chas. Evans Cemetery. Mohnsville quarries.
Schaefferstown:
Thurber's residence, entire from local quarries south of town.
Weigle's residence, entire from local quarries, south of town.
Scotland:
Soldiers' Orphan Industrial Home, base, entrance and trimmings. H. B.-S. Co.
Scranton:
Public school building, entrance, water-table and trimmings. H. B.-S. Co.
Laurel Run redstone, said to be used in Scranton, but no buildings specified.
Shamokin:
Trust building, base, entrance and trimmings. H. B.-S. Co.
Shippensburg:
State Normal School. ? Goldsboro quarry.
State College:
Engineering building, base, entrance and trimmings. H. B.-S. Co. (See p. 50.)
Steelton:
Foundation for machinery and blooming mill and for Bessemer engine. Goldsboro quarry.
Sunbury:
Public school building, base, entrance and trimmings. H. B.-S. Co.
Williamsport:
Susquehanna trust building, base entrance, piers and trimmings above. H. B.-S. Co.
Williamsport Hospital, water-table, steps and trimmings. H. B.-S. Co.
Torresdale, Phil'a:
Eden Hall. ? Newtown quarry.
Wilkesbarre:
City Hall, base, first story, entrance and trimmings above first story. H. B.-S. Co.
Y. M. C. A. building, entrance, first story, piers and all trimmings. H. B.-S. Co.
St. Nicholas German Catholic church, entire, William Schickel, architect. Laurel Run Redstone quarries. (See Plate 4.)
First Presbyterian church, entire, J. C. Cady, architect. Laurel Run redstone quarries.
Baptist chapel, entire. Laurel Run redstone quarries.
Residence of E. C. Frank, base and first story front, A. H. Kipp, architect. Laurel Run redstone quarries.
Residence of S. L. Brown, base and bay window, A. H. Kipp, architect. Laurel Run redstone quarries.
Ninth regiment armory, base, entrance and trimmings; M. B. Houpt, architect. Laurel Run redstone quarries.
A great deal of Laurel Run redstone used in Wilkesbarre for foundations, retaining walls, curbing, etc.
York:
Residence of Judge Stewart, base, first story, entrance and trimmings above. H. B.-S. Co.
Colonial Hotel, water-table, entrances, porches and trimmings. H. B.-S. Co.
United States court-house and post office, base, water-table, column caps, arches at entrances and trimminges. H. B.-S. Co.
York Collegiate Institute, all of the trimmings. H. B.-S. Co.
Residence of Mr. W. M. Kurtz base, entrance and trimmings. H. B.-S. Co.
St. Paul's church. ? Goldsboro quarry.
Tenth census report, 1880, states that the Goldsboro brownstone was used to considerable extent.

FLORIDA.

Orlando:
Orange county court-house, approaches, water-table and trimmings. H. B.-S. Co.

MAUCH CHUNK COURT HOUSE.

Showing the use of Pennsylvania brownstones in public buildings. The face work of White Haven red stone, entrance and trimmings of Hummelstown brownstone.

ILLINOIS.

Chicago:
Residence of Mr. Wellman, Beethoven Place, between Wells and Sedgwick streets, base and trimmings. H. B.-S. Co.
Residence of Mr. King, Michigan avenue and Harrison streets, base and trimmings. H. B.-S. Co.
Residence of John Heiland, 1506 Michigan avenue, base and trimmings. H. B.-S. Co.
Residence of K. A. Shaw, Jackson and Laflin streets, base and trimmings. H. B.-S. Co.
Residence of Mr. Nash, Ashland avenue near Harrison street, base and trimmings. H. B.-S. Co.
Apartment buildings of Mr. Johnson, 212-216 Indiana street, base and trimmings. H. B.-S. Co.
Mr. Keniston's building, Carpenter and Madison streets, base and trimmings. H. B.-S. Co.

INDIANA.

Indianapolis:
Union Station, stone trimmings above base. H. B.-S. Co.

MARYLAND.

Gapland:
Army Correspondence Memorial Arch, arches, tablets and trimmings. H. B.-S. Co.
Hagerstown:
Administration building. ? Goldsboro quarry.
La Plata:
Court-house, entrance, water-table and trimmings. H. B.-S. Co.
Rockville:
Court-house of Montgomery county, entrance, water-table and trimmings. H. B.-S. Co.

MISSOURI.

St. Louis:
Residence of William Clark, base, entrance and trimmings. H. B.-S. Co.

NEW JERSEY.

Camden:
Catholic church. ? Yardley quarry.
Elizabeth:
Senator Corvin's residence. ? Lumberville quarry.
Mount Clare:
Residence of Col. Fellows, entire facing and trimmings. H. B.-S. Co.
Orange:
M. E. church, entire facing and trimmings. H. B.-S. Co.
Princeton:
Princeton College, trimmings to one of the buildings. Newtown quarry.

NEW YORK.

Belona:
Belona Baptist church, water-table and trimmings. H. B.-S. Co.
Brooklyn:
St. John"s Hospital. ? Lumberville quarries.
Clifton Springs:
Sanitarium, approaches, porch, doorway, and all trimmings. H. B.-S. Co.
Elmira:
Belgian blocks in the streets. White Haven quarries.
New York City:
Market and Fulton National Bank, W. B. Tubby, architect, base, entrance and trimmings. H. B.-S. Co.
Pottier and Stymus building, S. D. Hatch, front entirely of dressed, rubbed and carved stone. H. B.-S. Co.

OHIO.

Cleveland:
Residence of Mr. S. F. Everett, C. F. Schweinfurth, architect, entire facing and trimmings. H. B.-S. Co.

Cleveland—continued:
Arcade building, G. H. Smith and Jno. Eisenmann, architects, entrances, first story piers, and cornice and trimmings above. H. B.-S. Co. (See Plate 15.)
Wade Bank, doorway, base and trimmings above. H. B.-S. Co.
Residences of Messrs. Warner and Swasey, base, entrances, porch and trimmings. H. B.-S. Co.
Dayton:
Residence of Col. Platt, base, entrance, porch and trimmings. H. B.-S. Co.
Salem:
Pennsylvania Railroad Station, base and trimmings. H. B.-S. Co.

VIRGINIA.

Abington:
United States court-house and post office, trimmings. H. B.-S. Co.
Leesburg:
St. James' church, entrances, water-table, and trimmings. H. B.-S. Co.
Washington, D. C.:
Residence of Senator Hurst, W. H. Miller, architect; base, porch, entrance, and trimmings.
Residence of Senator Sawyer, entire facing and trimmings.
Residence of Hon. Levi P. Morton, base, entrance and trimmings.
St. Joseph's Roman Catholic church, P. N. Dwyer, architect; entire facings and trimmings.
Richmond Flats—base, first story, and trimmings above.
Cochran Hotel—base, entrance and trimmings.
Albaugh's Opera House—base, first story, and trimmings above.
Albany Flats—base, first story, and trimmings above.
Bureau of Printing and Engraving—trimmings and entrance.
Residence of Hon. James G. Blaine, trimmings.
Residence of Senator John Sherman, trimmings.
Residence of Senator J. D. Cameron, trimmings.
Residence of Jerome Bonaparte, trimmings.
All the above Washington buildings are of H. B.-S. Co. stone. Goldsboro brownstone is said to have been used in Washington.

WEST VIRGINIA.

Bluefield:
People's Bank, entrance and trimmings. H. B.-S. Co.

Statistics.— The statistics of the brownstone production in Pennsylvania could not be obtained in a very satisfactory manner. Some of the quarries were not in operation at the time of my visit to them and the parties could not be seen personally. A few refused to give the production of their quarries; while some of the others would give only the average for the last six years. The figures of production that were obtained from the majority of active producers were combined with the averages given by others, and to these were added conservative estimates of the remainder. The figures obtained in this way are here given:

Value of brownstone produced in Pennsylvania since 1890.

	Values given by quarrymen.	Estimated values.	Total for the year.
1891,	$348,000	$69,000	$417,000
1892	353,700	82,000	435,700
1893,	346,900	80,000	426,900
1894,	340,400	71,000	411,000
1895,	351,200	70,000	421,200
1896,	325,000	55,000	380,000
Value of average yearly production since 1890,			$415,300

The above does not include any estimate on production of the quarries at Phoenixville, Mount Clare, Valley Forge and vicinity, Conestoga Valley, Mocanaqua, Rockwood, Ellwood City and the quarries in the vicinity of Hummelstown outside of the Hummelstown Brown-Stone Company, because there are not sufficient data available to give such an estimate any value. Nor does it include any estimate on the purely local usage of the stone where there is no established quarry. And this is an important source in the aggregate, as in Lancaster, Lebanon, Dauphin, York, Berks, Chester, Bucks and Montgomery counties there are a great many farm buildings and country residences constructed from stone taken from outcrops on the farm or immediate vicinity.

The estimates were based on comparison with other quarries in the same district, from the number of men employed, the uses to which the stone was put, the time it was in operation, the size of the opening and other things. The list above on which no estimates were given includes those quarries of which we had not sufficient data to make a rational estimate. From the information at hand I feel safe in saying that the value of the total production of brownstone in the State would be not less than $450,000 and possibly not less than a half million dollars per year. However, the distribution through the six years would be different from that shown on the table, as some of the largest producers gave their product only in the average annual output and as we had no data for distributing it, it was counted the same for each year. Hence the product for '95 and '96 would be less than that shown on the table and that for '91 and '92 much more making the yearly average the same.

PART II. LOCAL FEATURES OF THE BROWNSTONES OF PENNSYLVANA.

General features of the New Red area.—The New Red* is a name commonly applied in this State to a series of rock strata in southeastern Pennsylvania of age more recent than the Carboniferous and commonly supposed to correspond to the Triassic, and possibly Jurassic in part, division of the Mesozoic.

It forms a belt of varying width extending through southeastern Pennsylvania from New Jersey to Maryland and including nearly all of Bucks and Montgomery counties and parts of Chester, Berks, Lebanon, Dauphin, York and Adams counties. This forms but part of an outcrop extending along the eastern part of the United States between the Allegheny Mountains and Blue Ridge from Massachu

*Dr. Lyman in his excellent treatise on the New Red of Bucks and Montgomery counties and in a paper in the Journal of Geology, gives reasons for retaining the name New Red in preference to Newark, Connecticut, Jurassic, Triassic, Mesozoic, and other synonyms.

setts to North Carolina but broken into separate areas.* The stone occurs and is quarried in Massachusetts, Connecticut, New York, New Jersey, Maryland, Virginia and North Carolina.

It is made up of a series of shales, sandstones and conglomerates, for the most part of red brown color but varying widely in different localities. Dr. Lyman as a result of his investigation in Montgomery county makes the total thickness of the whole series in that county 27,000 feet subdivided as follows:

	Feet.
Pottstown shales, red shale with a few scattered green layers,	10,000
Perkasie shales, green and dark red or gray shales,	2,000
Lansdale shales, red shales with a few scattered green layers,	4,700
Gwynedd shales, black, dark gray, and red or green shales,	3,500
Norristown shales, red shale, brown and gray sandstone and conglomerates,	6,100
Total,	27,000

As will be seen, the brownstone occurs in the lower group of the series according to this classification. No attempt was made in the present work to carry this correlation westward into the neighboring counties, or to correlate the different deposits found there, as there was not sufficient time available to give such work any value. The Mohnsville, Cornwall, Hummelstown, Goldsboro beds while they are thought to be the stratigraphic equivalent of the Norristown, Newtown, Yardley, Lumberville beds, they were not so proven and because of lack of time no attempt was made to prove whether the lower part of the series including the brownstone was of Permian age as thought by Dr. Lyman, or of more recent age as argued by other writers.

There has been considerable discussion about the apparently great thickness† of this formation in different localities. The only part that has a direct bearing on the present discussion is the thickness of the beds of workable sandstone and of the material separating them. The workable sandstone is in beds varying from a few feet to a hundred feet or more. If one includes the interstratified shale layers a thickness of several hundred feet might be obtained at either Lumberville or Hummelstown. There is probably a greater thickness of good stone in proportion to the amount of shale in the

* See maps in Dr. Lyman's report, Pa. Geol. Survey-Summary. Final Report, or in Bull., 85 U. S. Geol. Survey.

† The reader is referred to Bull. 85 of the U. S. Geological Survey for a review of the whole subject and literature bearing upon it.

vicinity of Lumberville than in any other locality. At Newtown and Yardley the bed is 30 to 40 feet, at Grenoble and Fort Washington about the same. At Norristown it is 50 feet or more, at Mohnsville about 30 feet, at Hummelstown 50 feet, and at Goldsboro 12 to 15 feet. At most places where the sandstone occurs there is a succession of several beds separated by intervening beds of red shale and conglomerate, the value of the deposit depending upon the relative proportion, position, and character of the sandstones.

So far as known, the shales have no economic value further than that the harder forms are used in places for road metal and in two places, Mount Clare and Birdsboro, they have been used for building material.

Some writers have supposed that all the strata of the series have a uniform dip north to northwest of 10 to 25 degrees, but such has been shown not to be the case. While the west of north dip is the more prevalent one it is not the only one as shown on Dr. Lyman's sections,* and as may be seen in a field examination.

The deposits were formed in a comparatively narrow lake, bay, or arm of the sea, which was in a general way parallel with the present coast line, and limited by the older rocks on each side. The beds of sandstone and shale were formed by the filling in of a depression not unlike the present great Valley of the Appalachians, which would be an inland sea or bay if the east coast were to be depressed. Part of the materials, the coarse conglomerate, was deposited by rapid streams or currents and part, the shales, in comparatively still water, the sandstones forming an intermediate grade. Whether we consider Dr. Lyman's estimate of 27,000 feet or a greater or less thickness, we see that the greater portion of the whole is composed of shales, a comparatively small part of sandstones, and a still smaller per cent. of conglomerates, but the proportion is by no means uniform. Thus at Portland, Conn., there is a thickness of more than 500 feet of nearly all sandstone with some conglomerate and very little shale. In the vicinity of Mohnsville, Birdsboro, Schaefferstown and Cornwall there is a great deal of conglomerate, some of it very coarse. West of the Susquehanna shales appear to predominate with but little sandstone or conglomerate.

Throughout the entire brownstone area both in this and other states there are considerable areas of trap rock, which occurs intercalated between the layers of sandstone and shale, cutting through them in dikes or covering the surface in boulders, without showing the method of extrusion, and which has been utilized for road material and to some extent for building stone.

*In the Atlas to the summary Final Report, Pa. Geol. Surv., 1893.

A. Detailed Description of the Southwest Part of the New Red Brownstone Area.

Hummelstown, Goldsboro and Vicinity.

Hummelstown. — The Hummelstown brownstone, which is so well and favorably known by most of the architects and builders throughout the country derives its name from the town of Hummelstown, which is located ten miles east of Harrisburg, and one hundred and three miles from Philadelphia, on the Lebanon Valley branch of the Philadelphia & Reading Railway, and is, therefore, within a few hours distance from Philadelphia, New York, Baltimore, Washington and the other principal cities of the east.

Hummelstown is an old settlement, having been laid out by Frederick Hummel in 1762, who named it Fredrickstown, which name was afterwards changed to Hummelstown. It is older as a town than Harrisburg which was not laid out, as a town, by John Harris, until 1784.

The deposits of brown sandstone are found in the hills southeast, south and southwest of the town, and have been used, locally for tombstones and building purposes from about the time of the first settlement. Tombstones, in excellent condition, dating back to the earlier years of 1700 can be found in all of the old burial places in the vicinity. Many of the old houses and barns are built of the same stone.

The Hummelstown brownstone, as it is the most extensively quarried and best known brownstone of the State, deserves more than a passing notice. It is in fact the only native brownstone that is widely known outside of the State. Stone from other localities has been shipped out of the State, but in small quantities compared with that which comes from the Hummelstown quarries. As the stone varies somewhat in the different openings, different varieties will be described under the heading of the company that owns the quarry.

There are a dozen openings from which considerable stone has been taken. Four of these are worked by the Hummelstown Brown-Stone Company, one was operated by the Pennsylvania Brownstone Company, one by the Middletown and Hummelstown Company, one by Hartlieb Brothers, of Lebanon, one by Francis Painter and Company, of Derry Church, one by the Stoverdale Brownstone Company, one by the Co-operative Brownstone Company, two by the American Brownstone Company, one by Mr. Hummel. Besides those enumerated there are smaller openings of purely local importance.

Hummelstown Brown-Stone Company — While nine different companies have operated quarries in recent years in the

VIEW IN QUARRY NO. 1, HUMMELSTOWN BROWN-STONE COMPANY.
Showing dip of strata and method of working.

RESIDENCE OF SENATOR SAWYER, WASHINGTON, D. C.
Showing use of Hummelstown brownstone in private residences.

vicinity of Hummelstown, the only one in operation at present is the Hummelstown Brown-Stone Company. This is due partly to the more favorable location of their quarries, with reference to the quantity of good stone obtainable, their shipping facilities, the amount of capital invested, and in no small degree to the business tact, energy, and perseverance of the managers which enable them to continue in successful operation during a business depression like that of the present. Believing that they had a good stone which was needed in the market, they gave their time and energy to pushing it into prominence, enlarging their facilities when necessary to meet the demand.

Probably the first regular quarry opened in the region was one, now belonging to this company, located on what was known as the Berst property. A farm house near the quarry built entirely of this stone was erected in 1800. The corner stone bearing the date shows the tool marks as perfectly as when first dressed. (See Plate 2 p. 22.) Stone was quarried on this property to enlarge the locks on the Union Canal in 1853-58. It was also used for bridges and culverts on the Lebanon Valley Railroad, built about the same time.

In all probability it was the quarrying of the stone for this work which first called the attention of stonecutters and contractors from a distance to its value as a building stone, for after this time (1858) there was a continuous trade in stone from this locality, and building stone such as steps, door and window sills were shipped either by canal or rail, to all the larger towns in the adjacent counties.

The quarries of the Hummelstown Brown-Stone Company on the Berst property, were worked in 1860 by Henry Brown, of Harrisburg, who began by taking out stone for the Dauphin County Court-House at Harrisburg. He continued the work by shipping stone to various places, and formed a company under the name of the Pennsylvania Brown Freestone Company, who in 1866 built the first stone saw-mill in this locality. In the fall of 1867 the management of this company was taken by Allen Walton, an enterprising and energetic business man from Philadephia, who immediately set about to extend the business and increase the trade. In 1868 he introduced the stone in the Philadelphia market, and about the same time in Baltimore, Md., yearly increasing the output, which went to Philadelphia, Baltimore and all the larger towns in Pennsylvania.*

The panic of 1873 adversely affected the business, after which time, some of the stockholders were not disposed to invest and en

*Dr. Julien in a paper before the New York Academy of Science in 1883 (page 222 trans.), says: "In addition to the varieties of brownstone already described there is one quite recently introduced into this city (New York) from Hummelstown, Pennsylvania, in a building on Fifth Avenue, above Forty-first street. It has been largely used in Philadelphia and is said to resist the weather well.

large the plant and increase the business, as others thought should be done; so, in 1877 Allen Walton and Philip Dougherty, who jointly owned about one-half the stock, purchased at sale the entire plant, real and personal, operating the quarries under the name of the Hummelstown Brown-Stone Company, and set about further to extend the business. They furnished the stone used in the new building erected by the Government for the Bureau of Printing and Engraving, and a number of other buildings in Washington, D. C. In the same year a market was opened in Richmond, Va. In 1881 Allen Walton purchased Mr. Dougherty's interest in the quarries and individually continued to operate them under the name of Hummelstown Brown-Stone Company, selling stone in the New York market in 1882, Cleveland, O., in 1883, Chicago, Ill., in 1885, St. Louis, Mo., in 1886, Indianapolis, Ind., in 1887, and Orlando, Fla., in 1888, thus largely extending the trade and giving the stone a wide reputation. In 1886 he built a railroad four miles, connecting the quarries with the Philadelphia and Reading Railroad at Brownstone Station, on that line, and in the same year built a saw-mill at the quarries, abandoning the old mill which was located at Hummelstown. In 1891 he deemed it advisable to incorporate the Hummelstown Brown-Stone Company and to separate it from the railroad, and incorporate that as the Brownstone and Middletown Railroad, of both of which companies he is the president. The active management of the stone business is now largely in the hands of his two sons, although the elder Mr. Walton remains president of the company. The several quarries are equipped with thirty steam derricks, one heavy capacity steam shovel, three steam cable hoists, and a complete line of steam drills, quarry bars and other quarrying tools. The mill and stone dressing shops are extensive, containing 13 gangs of saws, 14 stone planers and stone lathes. The hoisting about the mill and shop is done by two heavy capacity steam traveling cranes, running back and forth on trestle work. From 500 to 700 men are employed at times, the number increasing with increased orders.

The plant further consists of machine, carpenter and blacksmith shops, all fitted out with a full line of tools and machines.

The railroad consists of a line, as before stated, with extensive sidings at Brownstone and at the quarries and is equipped with four locomotives, three passenger coaches and thirty-four cars, used principally for transferring stone from the quarries to the mills and shops.

The capacity of the quarries is practically unlimited, having always been able to meet every demand, and being able to supply any size or quantity of stone ordered, one reason for the increased trade being the promptness and certainty with which all orders are filled, which means a great deal with contractors.

Entrance to Engineering Building, State College, Pa. Showing the use of Hummelstown brownstone in doorways.

Structure of the Hummelstown stone. — The strata in and about the quarries all dip about 40 to 45 degrees to the north, thus giving the strike or the line of out-crop an east-west direction. The separate layers vary from 20 inches to 20 feet or more in thickness. While the bedding planes are not abundant, and where they do occur are not conspicuous open seams, yet there is throughout the bed an easy cleavage parallel with the bedding on which the layers can be readily split into any thickness desired. These seams are more abundant near the out-crop and least so in the bottom of the quarry. The joint seams in these quarries are not numerous and not very regular. There are are a few incipient cracks due to the bending or folding of the strata.

The total thickness of the stone is not known. Including the conglomerate, sandstone and the shales there is certainly not less than several hundred, probably several thousand feet. The greatest thickness of good quality of brownstone at one place is about 50 feet, as shown in nearly all the quarries of this company. But while this 50 feet is immediately underlain and overlain by red shale and conglomerate good stone is known to occur, both above and below the bed quarried. In fact, one of the quarries is in layers that underlie those in the other quarries, and the Pennsylvania Brownstone quarry to the north is in overlying layers with out-crop of good stone between. Thus the supply of good stone is practically unlimited. The only question is the economic production of it, which question the company has answered successfully so far.

There is a possibility, of course, of east-west faults causing a repetition of the same layers in successive out-crops, but there is no evidence in favor of this theory, not even in the character of the rocks in different places.

Texture of the Hummelstown stone. — The stone varies somewhat in texture, there being fissile red shale, fine grained sandstone and both shale and quartz conglomerate, but there is not such an intermingling or gradation of these one into another as is noticeable in some brownstone regions. The series alternate but rarely mix, except in some places where there is a mingling of the shale fragments with the sandstone. There are heavy layers of coarse quartz pebbles in the series, but the little patches or thin bands of pebbles running through the good stone as observed in some localities do not occur here. The first-class stone is an even fine grained stone, remarkably uniform both in texture and color, probably unsurpassed in this property by any brownstone in the United States, certainly not by any that occurs in similar large quantities, so far as observed by the writer. One of the greatest defects in the majority of brownstone deposits is the lack of uniformity in either color or texture or both.

The texture of the Hummelstown stone is close, the grain fine, and it will take a very smooth finish. While the actual absorption of the stone is not much below the average, the pores are small and the dressed surface smooth.

Color.—There are two decided shades of color in the stone from the different quarries. The most abundant shade and one that comes from all but one of the quarries is a reddish brown, a brighter, warmer shade than the average New England stone, but not so bright as one variety of the Michigan (Portage Entry) stone or the English red stone, more nearly resembling the East Longmeadow (Massachusetts) stone in color than any other now in mind. It is among the darkest colored ones in this State, those further east being almost all lighter colored, except that at Mohnsville and Frog Hollow. The other shade of the Hummelstown stone, a purplish brown, which comes from their quarry No. 3, harmonizes very well with the redder tint and buildings with the lower part of the purple stone and the upper part of the red stone, present a very nice appearance. In fact, either shade would make a nice trimming for the other.

Composition.—The two analyses given below show the chemical composition of the stone. The first one was made in the chemical laboratory at State College, the second in the chemical laboratory of the United States Geological Survey.

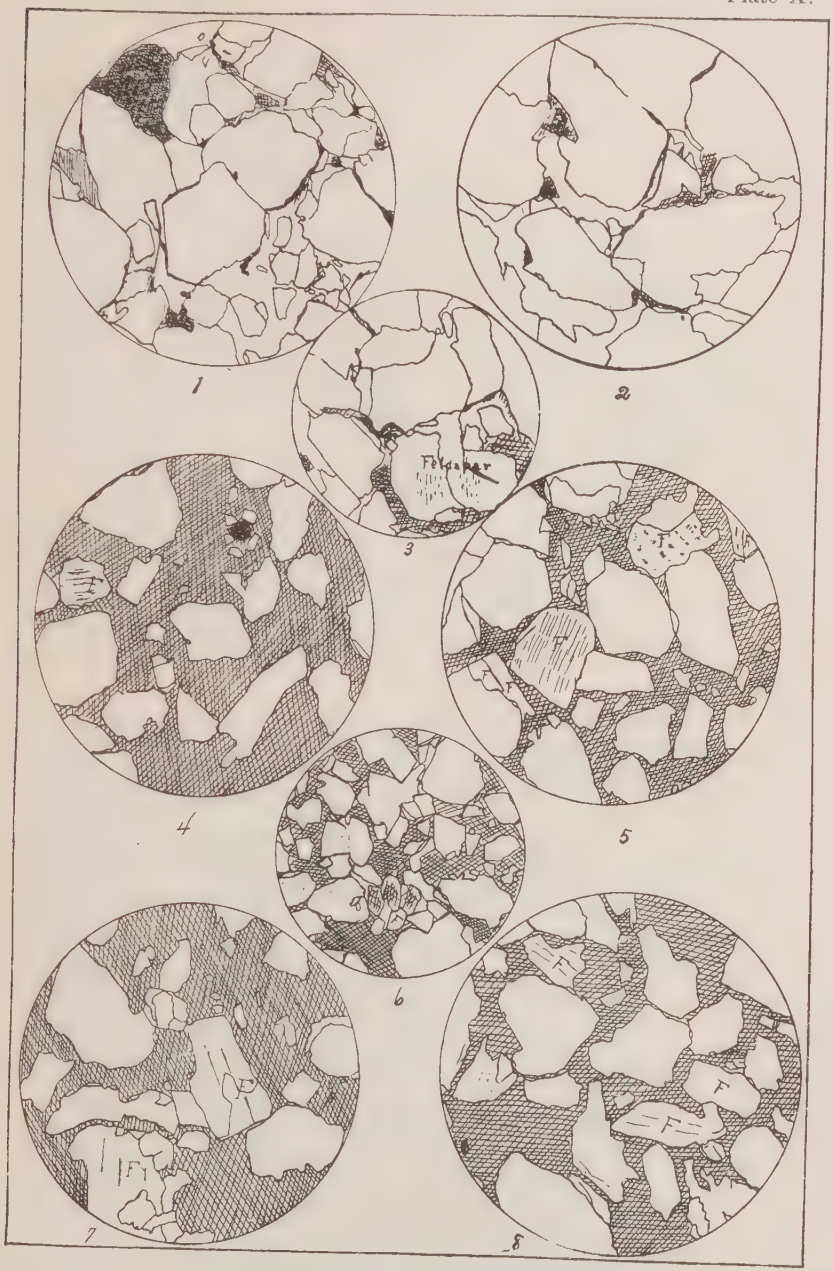
Chemical analyses of Hummelstown Brownstone.

	1 Per cent.	2 Per cent.
Silica (SiO_2),	90.341	88.13
Alumina (Al_2O_3),	4.350	5.81
Ferric Oxide (Fe_2O_3),	1.093	1.77
Ferrous Oxide (FeO),	.749	.31
Lime (CaO),	.953	.20
Magnesia (MgO),	.167	.53
Soda (Na_2O),	.188	.06
Potash K_2O),	1.299	2.63
Water,	.612	.49
Total,	99.744	99.93

Microscopical character of the Hummelstown stone.—The microscope shows it to be a stone made up largely of small angular (for the most part) quartz grains and numerous angular to subangular grains of feldspar in a cement of clay and iron oxide. The feldspar is much decayed and less abundant than in the stones farther east in the State or in the more eastern States. The grains appear to be pretty regularly diffused through the cement, with no pronounced lamination of the coarser and finer grains into separate layers or directing the longest diameters of the grains in the same di-

The mill, yard and some of the quarries of the Hummelstown Brownstone Company. Showing the topography of the region.

Brownstones of Pennsylvania. Plate X.



Microscopic sections of Hummelstown brownstone, magnified 44 diameters.
F signifies feldspar; cross-lined areas aggregates of clay, fine quartz, and iron oxide; mostly clay; very dark shading iron oxide; colorless areas quartz.
No. 1 –Pennsylvania Brownstone Co.'s quarry.
No. 2—Swatara quarry hard quartzose sandstone.
No.'s 4, 5, 7, and 8 Hummelstown Brownstone Co.'s quarry.
No. 3—An enlarged portion of a quartzose area from another part of No. 5.
No. 6—A less magnified portion, showing a larger area of No. 5.

rection, thus giving the stone a freestone rather than a flagstone character. The cement consists of clay mixed with iron oxide, the iron oxide appearing to be segregated in only a few places and there in but small particles. It is for the most part diffused through the clay in a very finely divided state and partially coating the grains in very thin pellicle. This would indicate that the iron was deposited simultaneously with the sand and clay, and that it has been modified very little since that time.

The figures on the accompanying plate (Plate X) are traced from the different parts of the sections viewed in the microscope (see also Nos. 4, 5 and 6 on Plate 1.) No. 6 is magnified 20 diameters, the others 44 diameters, drawn double the size and reduced. No. 3 is an exceptionally quartzose spot, looking almost as if there had been secondary quartz deposited among the grains. However, it may be but a shattered piece of quartz or a fragment of quartzite a little larger than the one shown on Plate 1.

Crushing tests of the Hummelstown brownstone from the quarries of the Hummelstown Brown-Stone Co.

Number.	Area, square inches.	First crack, pounds.	Total crushing strength, pounds.	Crushing strength, pounds per square inch.	Authority.
1	6.92	101,000	116,600	16,850	U. S. Government, Watertown Arsenal, 1897.
2	6.92	56,000	88,700	12,818	U. S. Government, Watertown Arsenal, 1897.
3	6.73	74,000	98,200	14,597	U. S. Government, Watertown Arsenal, 1897.
				14,753	Average of the Watertown tests.
4	7.13	103,600	104,236	14,619	Rose Polytech. Inst., Terre Haute, Ind., 1897.
5	6.94	101,800	102,447	14,761	Rose Polytech. Inst., Terre Haute, Ind., 1897.
6	7.26	91,334	94,528	12,580	Rose Polytech. Inst., Terre Haute, Ind., 1897.
				14,000	Average Terre Haute tests.
7	6.80	.....	100,240	14,740	Riehle Bros., Philadelphia, Pa., 1897.
8	6.80	.....	93,840	13,800	Riehle Bros., Philadelphia, Pa., 1897.
9	6.80	.....	96,050	14,120	Riehle Bros., Philadelphia, Pa., 1897.
10	6.80	.....	100,500	14,780	Riehle Bros., Philadelphia, Pa., 1897.
				14,360	Average Riehle Bros. tests of quarry No. 3 stone.
11	7.04	.....	70,660	10,090	Riehle Bros., Philadelphia, Pa., 1897.
12	7.04	.....	87,100	12,440	Riehle Bros., Philadelphia, Pa., 1897.
13	7.04	.....	79,040	11,290	Riehle Bros., Philadelphia, Pa., 1897.
14	7.04	.....	71,100	10,160	Riehle Bros., Philadelphia, Pa., 1897.
				11,100	Average Riehle Bros. tests, quarry No. 4.
15	9.375	.....	122,000	13,010	Riehle Bros., Philadelphia, Pa., 1890.
16	9.178	.....	122,000	13,290	Riehle Bros., Philadelphia, Pa., 1890.
17	9.375	.....	121,800	12,990	Riehle Bros., Philadelphia, Pa., 1890.
				13,100	Average Riehle Bros. tests, 1890.
				13,460	Average of all the tests on the Hummelstown stone.
				14,370	Average of all the tests on the Hummelstown stone, quarry No. 3.

The crushing strength of the Hummelstown stone, as shown on the accompanying table, is above the average for sandstones, standing intermediate between the common sandstone and the quartzite.

Bullitt Building, Philadelphia, Pa.

Residence of Mr. Ellis, Broad Street, Philadelphia, Pa.

Showing use of Hummelstown brownstone in business blocks and private residences.

In a list of tests on 62 specimens of the best known sandstones of the United States, including brownstones, given by General Gillmore in 1875,* there are 17 with a strength below 6,000; 43 below 9,000 and 49 below 10,000 pounds per square inch.

The specific gravity as determined in the laboratory at State College is 2.66, equivalent to a weight of 166.1 pounds per cubic foot. The specific gravity as given by Julien† is 2.35, equal to 146 pounds per cubic foot. A carefully dressed six-inch cube of the purple stone weighed 18 1-4 pounds, equal to 146 pounds per foot, which is practically the weight of the seasoned stone as it goes into the wall. A cube of the red-brown stone showed 150 pounds per cubic foot, which is the weight used by the company.

Durability.—There are several reasons for thinking that the Hummelstown brownstone is one of the most durable brownstones on the market. Both the chemical and mineralogical composition leave little to be desired in that line. The rock is composed of fine angular quartz grains with a very little undecomposed feldspar in a cement of clay and iron oxide. The relatively small quantity of the feldspar is shown both by direct examination in the microscope and by inference from the chemical analyses indicated by the small percentage of alkalies and lime (see p. 13). Clay, one of the chief residues from the decaying feldspar, in itself is one of the most durable of substances, but if present in large quantities in a rock with other constituents, is a source of disintegration by its property of absorbing water, which freezes and crumbles the rock. This is worse where the clay is segregated in patches and layers. Outside of this property it makes one of the best cements for sandstone, especially when mixed with iron oxide, because it binds the grains with sufficient firmness to make a strong rock, and yet not so firmly as to make it difficult to cut, saw, or break. The quartz cement is the most durable of all, but it makes the rock too hard for tool work. Lime cement is likewise too hard. So the only theoretical improvement that could be made in the chemical composition of the Hummelstown stone would be to have all of the feldspar changed to clay with the removal of all the alkalies and possibly a part of the clay. Yet the clay could not be decreased to any considerable extent without making the stone friable unless there was something else substituted.

With the exception of the natural outcrops, I have never seen any disintegration, scaling, or cracking of the Hummelstown stone, nor has inquiry among architects or stone dealers revealed any. As the quarries are not so old as the more eastern ones, it is difficult to make a comparison with them in this respect. The conditions, however, are these, that there are a great many brownstone fronts

*Appendix to Annual Report, Chief of Eng., U. S. A., 1875.
Trans. N. Y. Acad. of Sci., April 1--30, 1883.

in Philadelphia, New York and other eastern cities built of eastern brownstone which are disintegrating and scaling badly, most conspicuously so in the porches and courses next to the ground. So far as known to the writer there are none such of the Hummelstown stone. However, investigation has not been thorough enough on this line to say that there are none, nor to say that of those that are disintegrating none was built of stone which had been quarried since the Hummelstown quarries have been opened. It is not intended to state that all of the Hummelstown stone that has ever been used remains firm and uninjured, but simply to state that none of it observed or found on inquiry by the writer was scaling or disintegrating. Nevertheless, the evidence in this line combined with a comparison of the texture and composition is sufficient to guarantee the assertion that the Hummelstown stone is more durable than most of that used in brownstone fronts in New York, and that none of the other brownstones in the market of this country, so far as known to the writer, that are as easily worked as the Hummelstown stone are any more durable.

It is stated that the Hummelstown stone when first introduced into the Philadelphia market in 1868 was used by the architects principally for the base-courses of buildings built of New England brownstone. They at that time thought it was too hard to dress for trimmings or face work, but could be used for base-courses, as they supposed it to be more durable than the eastern brownstone, which was even then crumbling badly.

The 10th census report,* commenting on this stone, says: "The Hummelstown brownstone, the hardest and most compact of all these brownstones, has been introduced here (Philadelphia) within the last fifteen years, and is used principally for trimmings in buildings of other stones and in brick buildings, giving a very pleasing effect. This stone as yet shows no evidence of disintegration in any of the buildings in which it has been used, and has the reputation here of being quite substantial and durable."

Inquiries were made of a number of leading architects in different cities and those that replied without exception spoke highly of the durability of the Hummelstown stone.

The oldest building known to be constructed of the Hummelstown stone is a farm building, the Berst house, near the quarry, erected in 1800, in which the stone shows no sign of decay nor discoloration, but is apparently as strong and bright as when first laid. (See plate 2.) Another building nearly as old was observed at Hockersville, and there are no doubt others in the vicinity.

The Quarries.—The company is now operating at three different points, not widely separated, known by numbers as Quarry No. 1, No. 3 and No. 4. The No. 2 opening has been abandoned, as have

*Tenth Census, 1880, Vol. X, Building Stone, page 343.

Library, Mount Holly, Pa.

Westminster Presbyterian Church, Harrisburg, Pa. Showing the use of Hummelstown brownstone in public buildings.

Governor's Mansion, Harrisburg, Pa. Showing use of Hummelstown brown-stone in fronts.

several smaller openings on the hill north of No. 2. Quarries No. 1 and No. 3 are on the same ledge of rocks, and while at one time they were separate openings, intervening material has been worked out, and they now form one opening about 250 yards long and said to be 165 feet deep at the deepest point, No. 1 at the west end and No. 3 at the east end. The company does not contemplate any deeper workings at present, but are extending it laterally by working at each end.

The strata dip 40 to 45 degrees to the north, thus the strike along which the quarry opening extends runs nearly due east and west. As the opening is on the south side of the hill, the thickness of the over-burden increases rapidly with the depth of the quarry.

The stone, which is about fifty feet thick, is overlain by a heavy bed of red shale, mixed with conglomerate and streaks of sandstone. In some places it is underlain with red shale or a shaly sandstone, in some places by a soft conglomerate and in one place near the middle of the quarry an opening has been made through two or three feet of this conglomerate into 10 feet or more of good brownstone. The possibilities in this direction are inviting. The valuable stone in quarry No. 4 is taken from ledges that underlie those in Nos. 1 and 3. There are evidences of good stone still lower, and there is certainly good stone overlying the layers in the quarry, so that the bed worked in the quarry (Nos. 1 and 3) is but one of a series. As the strata change in character from point to point, it is impossible to tell with certainty what will be the economic character of the layers at any point until they are examined. So that the company, after exhausting the deposits at the present quarries, may find good stone in the under-lying layers so close that it might be worked more cheaply from the present quarry floor, than from a new opening.

The upper part of the accompanying plate (Plate VI) is a view taken in quarry No. 1, showing the disposition of the strata and the shape of the opening, the character of the overlying material and the bedding and jointing of the rock.

Quarry No. 4 is in active operation at present. It lies about 200 yards southwest of No. 1 in a lower series of strata, and on the opposite side of the valley, as there is a small lateral ravine from the southeast at this point, it is on the northeast point of the ridge. There is about the same amount of stripping as in quarry No. 1, but the overlying material differs in character, consisting almost entirely of conglomerate and sandstone, with very little shale. There is

about the same thickness of good stone exposed as in the other quarries, with a better prospect of good stone underneath the quarry floor. The accompanying figure (Fig. 2) is a general sketch across

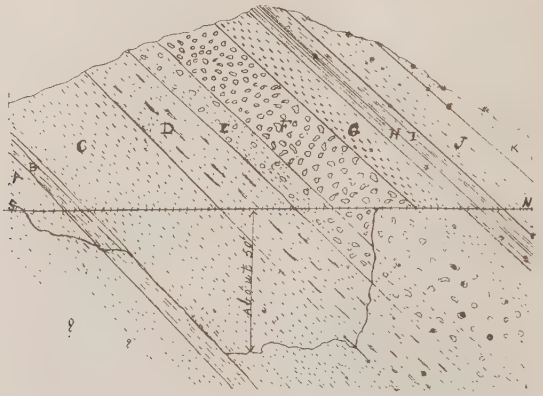


Fig. 2.—Vertical section across quarry No. 4. A, good brownstone thickness not known; B, shaly brownstone; C, good quality red-brown stone; D, second and third quality stone contains soft spots; E, pebbly sandstone; F, coarse conglomerate; G, uniform sandstone; H, I, red shale and shaly sandstone; J, brownstone weathered; K, brownstone much disintegrated. N—S railroad.

the west face of the quarry It shows the character of the rock exposed, the angle of inclination of the strata and the size and shape of the quarry opening. The railway track runs at the level of the black line connecting with the other tracks and the dump.

The methods of quarrying are adapted to the position and character of the stone. As may be seen from the position of the strata, the channeling machine could not be used to advantage. The steam drill and quarry bar are used with the Knox blasting system to loosen the stone in the quarry. It is then lifted by a steam hoist on one of the numerous large derricks or on one of the large wire cableways to the car, where it is transferred to the yard for scabbling or to the mill to be sawed, planed, or turned into the desired form. The stripping and waste of the quarry are loaded into large dirt boxes and lifted by derrick or cableway to the cars on the railway track and thence transported to the dump pile. Where the stripping consists of loose material its removal is facilitated by the use of a large steam shovel. The company has spared no expense in equipping the quarry with the most modern machinery for the rapid quarrying and handling of the stone.

The stone after it is prepared for the market is loaded aboard the railway car at the mill or the yard, the fine cut stone being packed in shavings, and transferred by the company's engine over their own track to the Philadelphia and Reading Railway at Brownstone station.

View of the stone sawmill and steam travellers for handling the stone at the Hummelstown Brownstone Company's Yard.

One can appreciate the growth of the stone industry at Waltonville by observing the forest of derricks, the numerous railway tracks to the different openings and different parts of the yards, the well equipped mill with its many workmen and mass of machinery, the locomotives moving about the yards, the clatter of the steam drills, the creaking of the steam hoists and the multitude of workmen scattered about the premises and then look at the old road wagon rapidly crumbling to pieces near Brownstone station and hear that all the stone shipped from Waltonville was at one time hauled on this old wagon.

The stone has been used in nearly all the large cities of eastern and central United States, and in many of the smaller ones. Philadelphia, New York, Washington and Baltimore are the largest markets. The stone has been used in some of the finest buildings in Washington. It has also been used extensively for bridges, piers and abutments. It is adapted to buildings of all kinds, and may be used alone or in combination with brick or other building stone. Some of its varied uses and its adaptability in architecture are shown in the accompanying illustrations, which show a few of the many buildings in which the stone is used. A list of the more important buildings constructed wholly or in part of this stone is contained in the general list on pages 39 to 44.

The Pennsylvania Brownstone quarry.—The Pa. Brownstone Co., Limited, was incorporated in the fall of 1886 by Samuel Fox, Wm. C. Erb and Edwin B. Erb, who leased property and opened a quarry on the north side of the hill, about two miles south of Hummelstown, the nearest railway point, and half a mile or more north of Waltonville. They built a stone mill at Hummelstown and invested a large sum of money in developing the quarry, and while considerable stone was shipped, the business proved unprofitable, possibly because of the large quantity of waste material to be handled and the long haul to the railway. In the fall of 1890 they sold their mill, quarry equipment, and lease to the Hummelstown Brown-Stone Co., who later purchased the land. It has not been worked since that time.

This quarry is near the north limit of the brownstone belt, and the strata still have the northerly dip as in the other quarries. Yet it varies to some extent from that in the quarries further south, the dip being not so steep and inclining more to the west, 25 to 35 degrees N., 20 degrees W., but not uniform. The thickness of the brownstone in the opening is about 50 feet and the opening is 80 feet or more in depth and about 60x100 yards in area. The stone is badly weathered to a depth of 20 or 25 feet, and contains many irregular seams throughout the greater part of the bed. The rock occurs in regular beds 10 to 20 feet thick, but the presence of the seams

or cracks in different directions through the rock causes considerable waste in quarrying the stone into rectangular blocks for dimension stone. Occasionally thin streaks of brown shale occur between the layers, and there is a little cross-bedding and ripple marks in places. The microscope shows it to be made up of sharply angular quartz grains, with chert fragments and an admixture of clay and iron oxides. There is a greater proportion of iron oxide and less of the clay than that examined from the quarries further south.

The quarry being on the north side of the hill, with the north dip to the rocks, there is not the constantly increasing thickness of the overlying material as in the quarries on the south side of the hill. However, the rock is more fractured and apparently weathered deeper than on the south side. Unless there is good stone underlying that exposed in the quarry it is questionable if first-class brownstone could be quarried as economically here as in the quarries on the south side of the hill.

Light colored brownstone of good quality outcrops in the soil in various places on the hill between the Pennsylvania quarry and the Hummelstown Brown-Stone Co.'s quarries, and future investigation may develop extensive quarries in this locality.

The Co-operative Brownstone Co. has made a small opening about one-half mile northeast of the mill of the Hummelstown Brown-Stone Co., in which there is a nice light reddish brownstone exposed, but the opening is too small (20-25 feet deep) to show anything about the quantity of good stone. So far as it is opened the stone is in small dimensions, being much broken by numerous irregular seams and much disintegrated near the surface. So far as known to the writer, no stone has been shipped from this opening. It is not in operation at present (1896).

The Stoverdale Brownstone Co. in the fall of 1895 made a small opening alongside the public road about one-half mile south of west of the Hummelstown Brown-Stone Co's quarry No. 4. The work ceased after a small quantity of the stone was shipped. The opening is not large enough to show how extensive the deposit of good stone may be. The strata dip 47 degrees N. 15 degrees W. in one place, but the dip is not uniform. There is a thickness of 10 feet of fairly bright colored brownstone overlain by several inches of brown shale followed by weathered brownstone shelly and full of seams. Underlying the 10 feet of good stone is other brownstone shelly and seamy so far as exposed. At a greater depth these weathered seams are liable to disappear, at least in part, and the stone become more solid, but whether the quality would be first grade and whether it could be removed with profit could only be determined by further investigation.

There are a number of old openings along the hill southeast of the Stoverdale quarry said to have been made by a Mr. Martin many

Market and Fulton National Bank, New York City.

Enlarged view of the doorway of the same.

Base, entrance and trimmings of Hummelstown brownstone.

years ago. Brownstone is exposed in all of these openings, but it is all badly weathered, none of the openings showing a sound stone of value, yet some of them indicating a possibility of obtaining good stone at a greater depth.

About a mile south of the Stoverdale quarry is an opening known as the *Hummel Quarry* which shows about 16 feet of brownstone of a pleasing color and nice, even texture, but so far as opened, containing numerous seams so that much of the stone would be in small dimensions. It could not be ascertained when this quarry was operated or how much stone was removed. But it has not been operated for a number of years, and it is said the principal reason for abandonment was the great number of seams.

There is a smaller opening a short distance west of the main opening in a mass of large boulders of fine looking brownstone.

American Brownstone Company.—A few hundred yards southwest of the Hummel quarry are two openings known as the Warner quarry and the Rupp quarry, which were opened by Jones and Collins, under the name of the American Brownstone Company, about the spring of 1890, and worked at intervals during the two or three years following that date since which time they have been idle.

The thickness of the good stone in the Warner quarry is apparently about 20 feet, but as it is inclined at a high angle, both the underlying soft conglomerate and the overlying shelly and shaly sandstone have crumbled and rolled down over the good stone and the bottom of the hole is covered with water concealing the greater part of it. The part exposed shows a stone of nice color and texture.

In the John Rupp quarry while the angle of the dip is but little different from the other quarries in the vicinity the direction of dip is markedly different, being nearly west (S 85 degrees W). In the Hummelstown Brown-Stone Co.'s quarries the dip is nearly north, in all the others it is a few degrees west of north, but in no other does it vary so much from north as in this quarry. The best stone appears to be in the bottom of the quarry, the lower 8 to 10 feet, the 15 to 20 feet overlying containing many seams. A small opening about fifty yards from the large opening shows a better quality of stone, but only a small quantity exposed.

The Middletown and Hummelstown Company opened a quarry on the Middletown and Hummelstown railway, about one and one-half miles northeast of Middletown. The quarry was well equipped with modern machinery, having a switch from the railway into the quarry, five large derricks and one small one, with steam hoists, and a mill equipped with two saw gangs. There is an electric plant which is said to have been put in after the quarry was abandoned. The quarry has not been in operation for a year or more, but particulars could not be obtained as to when it was opened, or how long it was

in operation, the amount of stone produced, where shipped, etc., in fact nothing but what could be obtained by a visit to the place and observing the empty quarry and the crumbling machinery.

The strata dip 25 to 30 degrees N. 60 degrees W. with the quarry opening on the southwest point of the hill, the stone thus dipping into the end of a steep hill. There is a thickness of about 20 feet of quarry stone underlain by a soft, shaly sandstone and overlain by a heavy bed of conglomerate, a mixture of quartz and shale conglomerate. This conglomerate is about 40 feet thick on the present quarry face and would thicken very rapidly on deeper quarrying. The stone in this quarry is softer than any of the other stone in this vicinity, many of the fragments lying about the mill and quarry being so soft as to be crumbled and broken in the hand. There are numerous spots of iron rust that give the stone a faint spotted appearance and appear to be one cause of the crumbling as the iron appears to be undergoing some chemical change.

The Erb quarry.—About two miles south of Swatara station Mr. Erb has made a small quarry opening on the northwest slope of the hill, where the strata dip about 32 degrees N. 65 degrees W. The stone has a nice, purplish color, even grain and texture, but is hard and brittle ("flinty") and contains many cracks and seams, particularly near the surface. At the bottom of the opening, probably 20 feet from the surface the seams are fewer in number, yet still abundant, and the rock continues brittle or " plucky." See plate X No. 1 for microscopic view of this stone, illustrating its hard or plucky nature in which it will be seen in comparison with the Hummelstown stone that the quartz grains are more numerous, closely compacted, with very little cement. That it is difficult to break can be inferred from a glance in which one can see that a fracture in the rock must break a considerable number of quartz grains and pull others from a closely felted mass of its fellows while in a free stone only the cement is broken, the grains pulling free from the cement on one side or other of the break.

The nature of the stone and the difficulty in getting the large dimensions will probably prevent the extensive production of stone at this point.

The *Swatara* quarry was opened by the Hartlieb Bros. of Lebanon, in the spring of 1894 and small quantities of stone have been shipped from there at intervals since that time. The quarry is a mile or a little more west of south from Hockersville and near the north limit of the brownstone belt. It is about 250 yards south of one of the large iron ore mines in the Trenton limestone that was worked extensively several years ago.

The strata are disturbed more or less so that the dip is not uniform, but in general it dips to the west and the north of west, in one

Arcade Building, Cleveland, O., and enlarged view of the entrance.
Entrance, piers and trimmings of Hummelstown brownstone.

place northwest 40 degrees. There is about 25 feet of solid, rather uniform brownstone, but it contains numerous seams. It is overlain by three feet of shale and soft sandstone, followed by 10 to 15 feet of sandstone and shaly conglomerate, followed in turn by much weathered brownstone that may prove to be good stone at greater depths. The quarry is not in operation this year (1896). Whether permanently or only temporarily abandoned is not known, letters of inquiry to the company eliciting no response.

The Derry quarry about two and one-half miles southeast of Hockersville was opened by Francis, Painter & Co., of Derry church, in the fall of 1884, and operated by them for four years, until the fall of 1888, when they disposed of their equipment and abandoned the quarry. The quarry has not been operated since 1888. The strata dip about 20 degrees N. 65 degrees W. and are quite regular with even bedding surface. The best stone, a beautiful fine grained brownstone, is about 16 feet thick, and is overlain by a brown shale and sandstone, some of which furnishes good stone. The quarry was fairly well equipped and worked rather extensively during the few years it was in operation, making an opening about 80 to 100 yards long and 40 yards wide at the top and 50 to 60 feet deep. The quarry has been cut down at one side so that the carts can go in to haul out stone. The other side has a nearly perpendicular face. The stone does not differ greatly from the other quarries in the region, being a little lighter in color, apparently more brittle, and having more seams.

The stone from this quarry was hauled to the Philadelphia and Reading R. R., a distance of about three miles, part of the way over exceedingly rough roads, which would certainly make a sad inroad into the profits on the stone. No particulars could be obtained regarding the markets, uses, etc., of the stone from this quarry, further than the statement that considerable stone was removed and shipped to Philadelphia, Baltimore, York, Lebanon, Harrisburg, and other points.

Brownstones of different shades outcrop in many places in the vicinity of these different quarry openings, some of which no doubt is of good quality and in which good quarries might be developed. However, as shown by the numerous failures in the way of abandoned quarries in the region, the work is attended with much risk, and one might make a dozen openings before striking a deposit of good stone of sufficient thickness and quality to be quarried with profit. Much of the money spent in the different openings has been squandered for the want of a little elementary knowledge of geology. It is a pure waste of money and time to follow a layer of conglomerate, or shale, or micaceous stone into the hill, expecting it to change to good stone. While there is a possibility that it may lose

some of its conglomerate character or that it may become less shaly with depth, the chances are equally as good for its becoming more conglomeratic or more shaly and the possibility of an entire change of character to very good stone within the limits of a quarry face is not one in a hundred. The only changes for improvement in the quality of the stone with depth that is reasonable to expect are fewer seams and less disintegration. The exposure of the stone at the surface allows the weathering agencies to open the incipient seams and some of the constituents to crumble, but the fragments of rock left in the soil will not be much unlike the rock at greater depth. Hence it is pure waste of money to make an extensive quarry opening in this or any other region without first making a careful examination of the surface conditions. Even then the risk is great enough, owing to the local changes in the character of the rock.

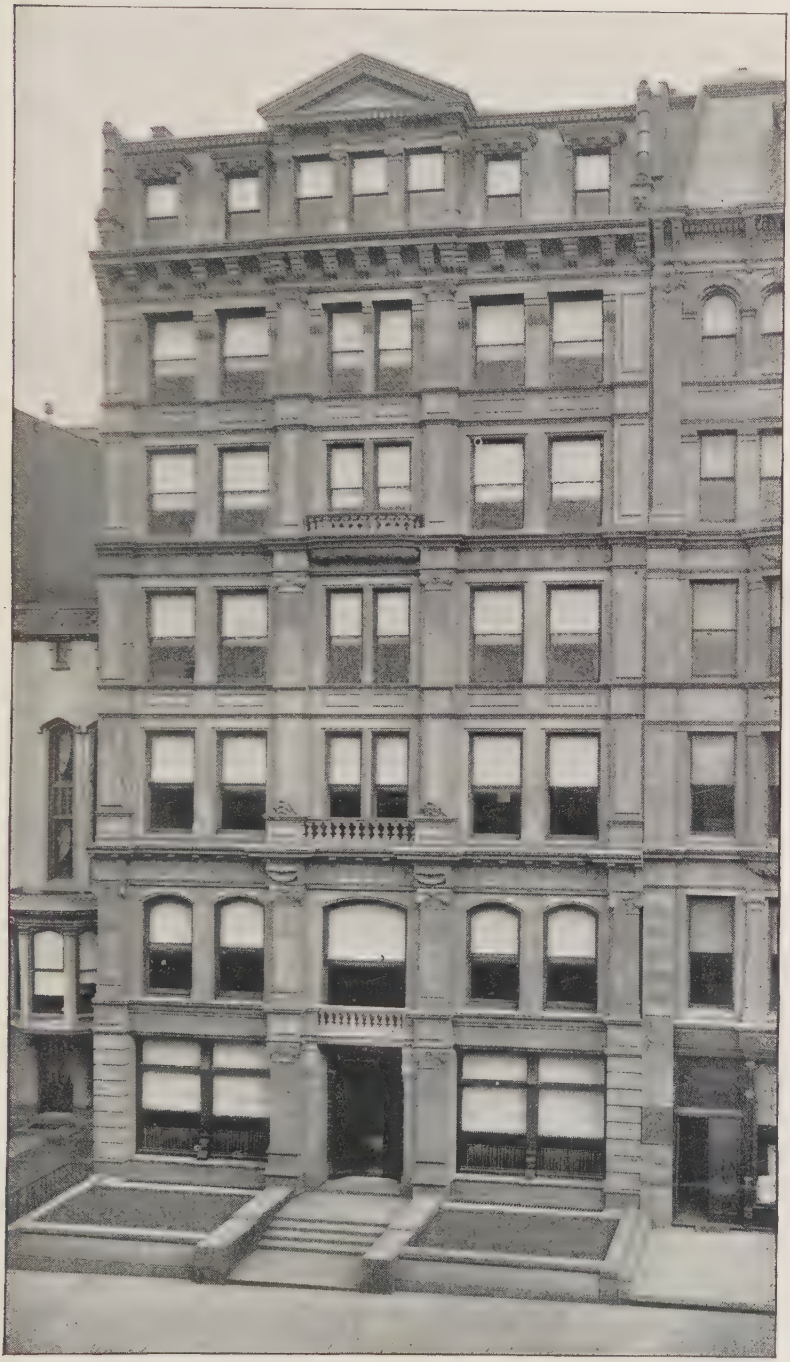
Goldsboro (Reehling) quarry.—So far as commercially developed, the part of the New Red formation west of the Susquehanna river is one of the least productive parts of this area in the State. The red shales and sandstones occur in a broad area, extending southwest through Adams and York counties, but so far as known the only quarry from which any stone has been shipped is the one near Goldsboro described below, and no others of any considerable local value could be found by inquiry in a hasty trip into the region. There was no opportunity for a personal investigation of undeveloped areas.

There is a large brownstone quarry on the Reehling farm about two and one-half miles west of Goldsboro, York county, that was opened in 1851 by Thomas Symington, of Baltimore, Maryland, and operated by him until 1856, when the property was purchased by George Betz, of Ashland county, Ohio. Mr. Betz operated the quarry for a few years, and J. H. Killwell followed him for a short time. August 20th, 1869, the quarry was leased by Frazer & Reehling, who were succeeded in the next April by the late C. F. Reehling, who operated the quarry continuously until 1880, when it was leased by the Hummelstown Brown-Stone Company, and has been idle since that date.

The nearest railway point to the quarry is Goldsboro, a station on the Northern Central railroad, on the west bank of the Susquehanna river, about ten miles below Harrisburg, and two and one-half miles distant from the quarry.

The cost of transportation by wagon from the quarry to the railroad was seven cents per cubic foot. The average annual output of the quarry from 1869 to 1880 is said to have been between 14,000 and 15,000 cubic feet, valued at that time at about $15,000.

The stone was used for base courses, steps, sills and other trimmings in buildings in many of the towns along the Northern Central railroad between Baltimore and Williamsport, and on the Cumber-



Pottier and Stymus Building, New York City.

Showing the use of Hummelstown brownstone in brownstone fronts. (Entire front of dressed brownstone.)

land Valley railroad from Harrisburg to Hagerstown. It was also used for bridge abutments, and to a limited extent for monumental purposes.

The stone has been removed from two quarry openings, one on each side of a shallow ravine from the north, which cuts through the ledge of rock nearly at right angles to the strike. In each one of the openings the stone has been worked east and west along the strike of the rocks about 100 yards, the openings being 40 to 50 yards across the top and 50 to 60 feet deep.

The strata are inclined 40 degrees, north 20 degrees west. The thickness of the bed of good stone appears to be about 12 to 15 feet both overlain and underlain by red shale. As may be readily imagined with a quarry bed of this thickness, inclined at this high angle, it could not be quarried to any great depth until the stripping would be too heavy to permit further deepening of the quarry with profit, and it becomes necessary to extend it lengthwise along the strike.

The rock is quite evenly bedded, with an easy bedding cleavage, so that after the stripping is once removed, it can be lifted easily and with little waste. It can thus be quarried profitably to a greater depth than a heavy bed of more refractory stone having numerous irregular seams.

The accompanying figure (Fig. 3), giving a section across the west

Fig. 3. Section across the Goldsboro brownstone quarry.

end of the opening, shows the position, the nature and thickness of the stone, and the shape of the opening. There is no opening to indicate the character of the underlying rock. Whether such has been made either by drilling or excavating could not be ascertained. The surface is everywhere covered with soil which is quite sandy, with numerous fragments of sandstone scattered through it, indicating that at least some sandstone occurs underneath the bed that has been quarried. Whether it is in commercial quantities and of good quality would require further investigation.

The laminated sandstone shown at (a) in the figure, occurring as it does on the perpendicular face of the quarry, could not be examined except at a distance. It appears to be too shelly or too much

broken at the exposure to be of any use unless perchance for very rough rubble work. It would no doubt improve in quality with the depth, but whether it would become sufficiently valuable to pay for the removal of the overlying shale, thus permitting the under stone to be worked deeper, might justify investigation, although the inducement is not great. The present condition so far as could be observed at the old opening, would rather justify investigation of the underlying beds if such has not already been done.

With the proper transportation facilities at the quarry, large quantities of good stone could be removed with profit at this place at the present price of stone. There is said to be another small quarry three-fourths of a mile north of the Reehling quarry, which was not visited by the writer. It is but a small opening, said to have been worked but very little.

About a half mile southwest from the Reehling quarry is a promising outcrop of brownstone, similar in color and texture to that in the quarry described above, but apparently in heavier layers, so far as can be judged from the boulders covering the surface. Judging from the sandy soil and the distribution of the boulders, there is a thickness of not less than 50 or 60 feet of sandstone, with possibly some intercalary shale and a little conglomerate.

There is an outcrop of brownstone and conglomerate in the village of Goldsboro, but it contains so many pebbles that it is doubtful if any good stone could be obtained. On the east bank of the creek, a half mile west of the village, there are a few thin layers of sandstone in a heavy bed of brown shale. On the west bank of the creek, near the iron bridge, some stone has been quarried for local use. In many places west of Goldsboro sandstone outcrops, and future investigation may show stone in commercial quantities.

Brownstone generally filled with pebbles occurs in many places in York county, but inquiry at different places failed to reveal to the writer any quarries even of local importance. Eli Seifert has quarried some coarse brownstone from surface rocks in the vicinity of Dover, and hauled it to York by wagon, a distance of eleven miles. Mr. Seifert says the stone is coarse and rough, and not fit for fine buildings. It was used for bridge coping and foundations.

B. Detailed Description of the Central Part of the New Red Brownstone Area.

Mt. Gretna, Cornwall, Schaefferstown, Mohnsville, Birdsboro, Phoenixville, Valley Forge, Port Kennedy, Norristown, Fort Washington, Doylestown and Grenoble.

Residence of S. F. Everett, Cleveland, O.

Showing the use of Hummelstown brownstone in private residences.

Mt Gretna.—Near Mt. Gretna station on the Cornwall and Lebanon railroad, Mr. A. G. De Huff, of Lebanon, opened a quarry in the New Red sandstone primarily for the sand. First loose sand from the disintegrating sandstone was screened and used. Later he put up a rock crusher and now crushes the weathered sandstone and screens that. In working this sand quarry he opened up some ledges of nice light brownstone, which has been used for building purposes. The accompanying illustration (Fig. 4) shows the depth of these ledges in the face of the said quarry.

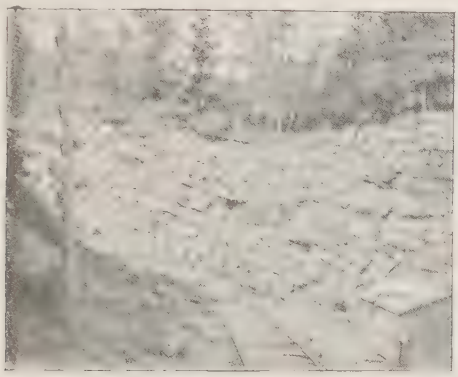


Fig. 4.—Mt. Gretna Quarry

As the primary object in this quarry is sand, the opening has not been carried to any great depth, as the weathered rock crushes most easily. The pit at the crusher has practically no good stone. The one back 100 yards from the crusher shows on the present face:

3—6 feet of soil and sand.

3 feet shelly sandstone

8—10 feet brownstone with a few weather seams.

1—2 feet red shale.

6 feet brownstone with streaks of pebbles.

The bottom of the quarry is in the brownstone. How much deeper it extends at this point is not known.

The brownstone has a uniform reddish brown color, lighter and brighter than the average brownstone. It has a rather sharp, coarse, angular grain, with streaks of pebbles an inch to two or three inches thick, not continuous, but often extending several yards, and in all cases parallel with the bedding, the stone having an easy cleavage in that direction, so that the pebbly streaks can be readily split from the other rock.

The little building stone that has been removed has been used in Lebanon. The weathered shelly stone, spalls, etc., are all taken through the crusher and rolls, ground into sand, screened and

shipped to Lebanon for use in the furnaces and in the building operations. The owner contemplates putting in a washer to wash the sand. The broken quartz pebbles that are not ground to sand between the rollers are screened out and thrown aside. These pieces, which are light colored and about the size of beans, would certainly make a fine dressing for roads or walks, or excellent filling for asphalt concrete.

Since the handling of the sand by itself is said to be a profitable investment, it ought to be made much more so by quarrying the building stone more extensively instead of using all surface material, and also by seeking a market for the quartz fragments now wasted.

Cornwall — There is no quarry regularly operated at Cornwall, but there are a number of buildings, probably 20 or more, constructed of brownstone, quarried from various points in the hills about the town.

The North Cornwall depot, offices and other buildings about the iron mines are constructed of this stone. The handsomest and most expensive of any of the buildings is the palatial mansion of Mr. Robert Coleman, standing in an unfinished condition, but on which it is said $125,000 have been expended. It is constructed entirely of this stone, with much fine carved work, and is a building of rare beauty. Care has been taken in the selection of the stone in the Coleman house, and as a result the stone is uniform in grain and color, and free from pebbles. In the other buildings the stone contains pebbles, which mars the beauty of the building to some extent, although it looks fairly well on a rock face.

In the country south of Cornwall as far as New Hope station, on the Cornwall railroad, there are many farm houses and barns constructed of stone said to have been obtained by quarrying the loose boulders and outcropping ledges in the adjoining hills. So far as is known to the writer, there is no established quarry in this region.

Schaefferstown and Kleinfeltersville. — There are several small streams breaking through the sandstone mountains south of Schaefferstown and Kleinfeltersville, flowing from the Lebanon limestone valley into the Lancaster limestone valley, through the intervening high sandstone mountains. Along these stream-courses, known as gaps, there are large quantities of brownstone exposed, much of it containing pebbles, but some layers free from pebbles, and most of it a warm, light brown color.

The gaps in which stone has been quarried are in order from west to east, Hammer Creek gap, Elizabeth Creek gap, Segloch gap and Middle Creek gap. No brownstone, as far as could be learned, has been quarried west of Hammer Creek gap, between that and Cornwall.

Along the hill on the east side of Hammer creek, considerable

stone has been quarried from the surface rock, nearly all of it, so far as could be observed, containing pebbles, and in no place worked to a depth of more than 8 or 10 feet.

Stone of better quality was observed in Elizabeth Creek gap than in any of the others. In three different places layers from 8 to 10 feet thick occur almost entirely free from pebbles. Stone in limited quantities has been taken out of this gap, as it has been in several others, and shipped to Columbia, Lebanon and Lancaster, for use in both plain masonry and trimmings, such as cornices, lintels, water tables, steps, etc. Considerable stone from these mountains is said to be used in Lancaster. Mr. Joseph Watson, of Schaefferstown, has been quarrying stone in a small way in the vicinity of Elizabeth gap for 30 years, using the product in the cities above named and in the smaller towns in the surrounding country.

The best stone observed in Elizabeth gap was on the property of William Wagner, in a branch ravine some distance from the Elizabeth creek.

Beautiful stone of good texture and pleasing color has been quarried in small quantities in this vicinity, but it is questionable whether it could be quarried profitably in large quantities, owing to the relative thinness of the beds free from pebbles, and the great quantity of conglomerate associated with it, with transportation facilities, so that the conglomerate could be quarried with profit in large quantities for bridge, stone or heavy masonry then the even-grained sandstone might be obtained in marketable quantities.

In Segloch gap surface stone has been quarried in small quantities, but so far as observed contains many pebbles. Coarse stone for heavy masonry could be obtained.

On Black Oak Ridge, on the west side of Middle Creek gap, south of Kleinfeltersville, the conglomerate brown sandstone outcrops in large quantities. The strata in this place stand nearly vertical (75 to 80 degrees, North 10 degrees East), the harder, more durable layers, projecting in dike-like walls in places. As at Segloch, the rock contains many pebbles. It has been quarried for local use in farm buildings and bridges; some is said to have been shipped for use in bridges on the Pennsylvania Railroad near Philadelphia.

The property from which the stone has been quarried in the Middle Creek gap belongs to Thurber and Weigle, each of whom has a nice residence in town erected of brownstone obtained from some one or more of these gaps in the mountains south of town.

The region between Middle Creek gap and Mohnsville was not traversed, as no quarries of even local importance were reported. The same is true of the middle and south side of the mountains through Lancaster county.

Reading.— In Reading brownstone from three localities has been

used: (1), the native stone from the hills about Mohnsville south of Reading; (2) the Hummelstown stone, and (3) the light pink stone from south of Birdsboro. The first of these, while of inferior quality to the others, has been used more extensively than the others because of its proximity to town.

Mohnsville — The stone known as the Mohnsville stone has been quarried from three openings on the sides of the valley about two miles south of Mohnsville. There are other abandoned openings, but only three now in operation. As the nearest railway point is Reading, nearly eight miles away, all the stone used in Reading or shipped to other towns must be transported by wagon that distance.

Stone has been shipped to Columbia, Pottstown and Minersville, yet the greater part of the product is used in Reading or the country adjoining, many country school houses and churches being built of it.

The buildings in Reading constructed of it are the Catholic church on Perkiomen Avenue, Keystone National Bank, the Stevens building, and several school houses and private dwellings.

The three parties quarrying stone at present (1896) are John Westley, Amos Price, and Daniel Shonour.

Westley's quarry is the one nearest to Mohnsville. Mr. Westley has been quarrying stone here since 1880 and now has quite an extensive stone trade considering the long wagon transportation.

The stone has a dark brown color as dark as the New England brownstone. It has a rather porous texture, a medium coarse grain, with a great deal of associated conglomerate, heavy beds of conglomerate overlying and underlying the sandstone bed in the quarry and pebbles scattered through the quarry bed. While much of the stone quarried is free from pebbles there is a great deal used with pebbles scattered through it more or less abundantly so that the stone is better adapted to rock-face work than to fine tool dressed work.

The quarry is located on the slope of the ridge 150 or 200 feet above the valley. The dip of the strata is a low angle to the surface of the hill and the strike runs at an angle to the direction of the hill, so that the quarry opening along the strike of the rock runs up and down the hill. On the upper side near to the top of the hill the opening has been carried along the hill with the dip, thus giving a face in two directions. The thickness of the bed quarried averages about 10 to 12 feet, a little thicker in some places. As it is underlain by conglomerate, a much greater thickness can be obtained by including the conglomerate. The accompanying illustration (No. 2 on Plate 14) shows the position of the stone and method of quarrying.

The next quarry above Westley's, but on the opposite side of the valley belongs to Amos Price, who has operated it for about six years previous to which he quarried from another opening about

Conglomerate from the brownstone south of Birdsboro. View on the bedding surface showing size and distribution of the pebbles.

View in John Westley's quarry, Mohnsville, Pa. Showing structure of the stone and method of working.

one-fourth mile from the present one for six or seven years. Price's quarry is worked less extensively than Westley's. It has a much smaller opening, the stone has a larger face, 25 to 30 feet, but the greater part of it contains pebbles. There is, however, a little very handsome brownstone, a better color and texture than any observed elsewhere in this region, but it is in such small proportion to the other rock that it has no great commercial value. The dip in this quarry is into the hill so that it cannot be worked as deep as the one on the other side of the valley, owing to the rapid increase in thickness of the overlying material.

Shonour's quarry is about half a mile up the valley (west) from Price's. The opening worked at present (Oct., '96). is on the south side of the valley, but there are several openings on each side of the valley, none of them of any great depth, as all the stone quarried has been taken from near the surface. As at the other quarries, there is much conglomerate and some nice sandstone.

The great quantity of associated conglomerate and scattered pebbles will prevent the Mohnsville stone from having a national reputation and ranking with high class building stones, yet its durability, comparatively large quantity, and ease of quarrying are sufficient to always insure a local market for it in moderate quantity.

Birdsboro.—There are four classes of stone in the vicinity of Birdsboro, which have been used for building: 1, a hard red shale; 2, a coarse red sandstone; 3, a light colored pink sandstone; 4, trap.

The red shale occurs in the immediate vicinity of the town. It has been quarried in the town and for a mile or more south of the town. There is no large quarry opening, but a great many small ones, from which stone has been taken for more than 30 buildings, mostly dwelling houses, in the town, and many farm houses in the surrounding country.

It is remarkable to find a durable stone in shale as it is the nature of most shales to crumble on exposure. This, however, contains considerable sand, probably an arenaceous shale and shows great durability. Some of the houses above mentioned are said to be more than 100 years old, built, it is said, as early as 1740, yet they appear to be in a good state of preservation. They are all a cheap grade of houses, many of them plastered with mortar spread over the outside of the wall. Part of the plaster has scaled off, showing a homely patchwork of brownstone and gray plaster.

There are two large quarries of the trap about a mile south of the village. Nearly all the trap rock quarried is used for crushed stone, 25 to 30 carloads per day being turned out. Some of it has been used for building.

South of the trap are heavy beds of red sandstone and conglomerate, some of the conglomerate being quite coarse. Two quarries both close together, have been opened in this rock along the Wil-

mington and Northern railroad, about 2 miles south of Birdsboro, on the east (here the south) side of Hays creek and on the north slope of the hill with the strata dipping nearly north at about the same angle as the slope of the hill, so that the surface of the hill at this place is nearly confined to one stratum of rock. The solid rock in many places outcrops on the surface over considerable areas and rarely has more than a few inches of soil covering.

In the lower quarry the stone has been opened at the base of the hill and up the slope to a height of about 100 feet and 20 to 25 feet deep. The upper opening is a little smaller.

The stone has a comparatively uniform dark brown color, not quite so dark as the New England stone. It contains a great many pebbles, some quite large ones, 4 to 6 inches in diameter. The pebbles are arranged mostly in irregular layers a few inches thick, scattered through the strata, but occasionally isolated ones will be found in the midst of fine grained sandstone. In places there will be a thickness of several feet free from pebbles, but in no place observed could this stone be quarried alone with profit, but by working the stone on a large scale and using the coarse stone for bridge work and heavy masonry, the fine grained stone could be obtained in marketable quantity, and the whole might be worked with considerable profit. See No. 1 on Plate 18, which shows view of the bedding plane in the conglomerate. This is from a photograph of a block which had split parallel to the bedding and was turned on edge. It is the coarsest part of the bed. Crushing tests on 2-inch cubes of stone from this quarry made in the Mechanical laboratory at State College showed results as follows: 41,500; 47,240; 48,640; averaging 45,790 or 11,448 pounds per square inch

Numerous exposures of the stone occur, both above and below the quarry in the valley, but so far as observed, none were less free from conglomerate than that in the quarry and in most places the pebbles were more numerous.

The quarry was opened by Mr. James Humphrey about 1890 and continued in operation for 4 or 5 years, but it is idle at present and the switch from the railroad partly torn up.

Further south in the valley and on the bordering hills considerable quantities of a handsome light pink sandstone has been quarried at different points, the most important points said to be near White Bear station on the Wilmington and Northern railroad. The localities were not visited by the writer, but stone dealers familiar with the region say there is no large quarry, but that the work has been altogether in surface stone obtained here and there where easy of access. There are several houses in Reading constructed of this light colored stone, the most expensive one being the residence of J. H. Sternbergh, one of the handsomest buildings in Reading, located opposite the entrance to the Chas. Evans cemetery. (See Plate 19, No. 2). The

Bucks County Court House, Doylestown, Pa., Lumberville and Yardley brownstone.

J. H. Sternberg's residence, Reading, Pa. Berks county pink sandstone.
Showing Pennsylvania brownstones in public and private buildings.

trimmings of this building are of light colored Indiana limestone. Mr. Sternbergh states that the stone for his house came from near Geiger's Mills near the line of the Wilmington and Northern railroad, about 15 miles south of Reading, and to the best of his knowledge had never before been used in Reading. He obtained all the stone from surface boulders and says that it has been quarried in considerable quantities since, but not in any defined quarry opening. Mr. Yocum's house, constructed of this stone, has the trimmings in brownstone. The gateway to Mr. Brook's house at Birdsboro is of this pink stone.

So far as observed this pink stone is not free from pebbles, but the pebbles are small, forming either a coarse sand stone with a few small pebbles or a fine conglomerate with much sand.

The stone presents a pleasing appearance in rock face work, both rubble and course work. The color is attractive and looks well either in walls or in trimmings, but the coarse texture renders it unsuitable for fine cut work. This stone while not regularly in the market, is known to the local dealers and quarrymen, and it is said can be procured on demand in small quantities.

Similar pink sandstone is said to occur also on the south side of the ridge in the Conestoga valley. J. H. Brinton of Thornbury advertises a pink stone from Conestoga valley, stating that it can be furnished in quantities for trimmings or ashlar, and that it is peculiarly adapted for trimmings for his Pennsylvania greenstone. A sample of this Conestoga pink sandstone received at the college resembles that used in Reading and Birdsboro, but a request for further information elicited no response.

The beautiful color of this stone and the demand for such stone at the present time would justify a careful investigation of this area.

Phœnixville. —Brownstone of inferior quality has been quarried in a number of places in the vicinity of Phœnixville

There is a small brownstone quarry on Bridge street in the west side of the town that is said to belong to Mr. Malin Miller. It is now abandoned and apparently has been for some time, for a number of years at least. The stone has been quarried over an area of a half acre or more to a depth of 20 to 25 feet with 5 to 20 feet of brownstone overlain by 6 to 10 feet of red shale. The stone has numerous seams, in places shelly along the seams. It has a dark brown color, darker on the surface than in the interior.

No information could be obtained regarding the time this quarry was in operation, the amount of stone produced or the use to which it was put.

There is a quarry on the hill above Mount Clare, just across the river from Phœnixville The stone on the quarry face is a dark

gray, rusty brown and black shale. What it was used for could not be ascertained, but it is apparently too much laminated for use as building stone. See No. 1 on Plate 20 for view in the quarry.

A small quantity of brownstone has been quarried at Berwyn, below Phœnixville for use in the water works at that place, but there is no regular quarry.

Mr. Gotwals, of Phœnixville, states that brownstone has been quarried in small quantities near Kimberton on the Pickering Valley railroad, also near Yerkes station on the Perkiomen railroad, on the property of John Gotwals and on the Buckwalter place, where stone was obtained for constructing the bridges when the railroad was built. Flagstone has also been obtained. None of these localities was visited by the writer.

Valley Forge.—Brownstone has been quarried along the Schuylkill river, both above and below Valley Forge. About mid-way between Valley Forge and Perkiomen Junction on the south side of the river is a brownstone quarry said to belong to Newton Walker, but it has not been operated for several years. The opening covers about a quarter of an acre, 15 to 20 feet deep. The stone which is of inferior quality, is of purplish brown color, coarse-grained texture, many joints and seams and much false bedding and intercalary shale. Some conglomerate occurs which contains both quartz and shale pebbles.

While but 15 to 20 feet of stone has been quarried the bed has a thickness of not less than 200 feet, some of the underlying stone being fully equal, if not superior, to that which has been quarried, yet it is all more or less defective throughout, containing streaks of conglomerate and shale. The bedding is not regular.

About mid-way between Valley Forge and Port Kennedy is a brownstone quarry said to belong to Charles Johnson. It has been opened recently and worked only on a small scale. There is a thickness of 15 to 18 feet of solid, coarse-grained brownstone.

Norristown, Port Kennedy and vicinity. — Large quantities of stone have been quarried in the vicinity of Norristown along both the Pennsylvania railroad and the Philadelphia and Reading railroad.

On the north side of the Schuylkill river there are quarries on the bluff on the east side of town, on the east side of Montgomery cemetery, on the west side, and at intervals along the Pennsylvania railroad up as far as Betzwood station, where the large quarry of the Port Kennedy Stone Company is located. On the south side of the Schuylkill there are quarries, on the west side of Bridgeport, and those enumerated about midway between Valley Forge and Port Kennedy and a mile or more above Valley Forge, below Perkiomen Junction.

The stone has had an extensive local usage for building and considerable quantities have been shipped to Philadelphia and vicinity.

Brown shale quarry, Mount Clare, Pa.

Kennedy's brownstone (light-colored) quarry, Fort Washington, Pa.

Quarries in the New Red formation in Montgomery county.

The stone in the immediate vicinity of Norristown, is of a gray color with a tinge of pink or purple, while that up the river from Norristown is all of a darker color from a light to a rather dark brown, but both the gray and the brown are interstratified with soft red shale.

The bedding of the stone is irregular, a layer six inches thick in one place may be two or three feet thick only a few yards away with lenticular masses of red shale inclosed. There are many joint seams, which are especially numerous near the outcrop of the layers, so that much of the stone is in small dimensions. Deeper in the bed the seams are much farther apart and near the bottom of the quarries, stone in large but irregular blocks can be obtained. Probably the large number of seams on the outcrop is due partly to the excessive use of powder in quarrying the stone.

The stone in most of the quarries is coarse-grained, there being a mixture of quartz and feldspar grains with a few mica scales. There are numerous streaks of coarse conglomerate in some of the quarries.

Part of the wall about the Catholic school and numerous buildings in Norristown have been constructed of stone from these quarries and it is said to have been used in bridges on both of the railways passing the quarries and for foundations in Philadelphia.

The quarry of the Port Kennedy Stone Company is at Betzwood station on the Pennsylvania railroad, on the north side of the river, opposite Port Kennedy. The quarry was idle October, 1896 and letters of inquiry to the company elicited no response so that it is not known whether the company is in existence now or not. Considerable stone has been quarried here at some time, the present opening covering four or five acres, 50 or 60 feet deep at the deepest part. The brownstone is overlain with three to ten feet of yellow sand and red shale. It has a medium dark brown color and occurs in irregular layers three inches to two feet in thickness, many layers wedging out entirely and masses of intercalary shale occur. Besides the irregular bedding seams there are many joint seams, especially abundant near the outcrop, so that throughout the upper part of the bed the stone is cut up in small dimensions suitable only for rubble or broken stone work. Near the middle and bottom of the quarry, stone of large dimensions can be obtained. There is some conglomerate present.

There is another smaller quarry of brownstone about half a mile east from Betzwood station, on the Pennsylvania railroad.

About a half mile below Port Indian station, two miles above Norristown on the Pennsylvania railroad is another brownstone quarry and three or four other small openings along the railways between this and Norristown. The stone varies somewhat in color and texture in the different openings, but is more or less defective in all. Near Port Indian it has a dark brown color, while in the

quarry below the cemetery, which is the largest opening of all, the stone is light colored and coarse grained. No particulars could be obtained in regard to the quarry as to when it was operated and the use made of the stone.

A church and several dwelling houses were noticed by the writer in Norristown that were constructed of stone similar in color and appearance to the stone in this quarry, and thought to be from this and neighboring quarries.

There is another quarry opening that was not visited by the writer in the lower (east) side of Norristown, that from a distance appears to have a light colored stone.

There are three quarry openings on the south side of the Schuylkill river, opposite Norristown and west of Bridgeport. The most eastern one of these, the one nearest town, is operated by J. L. Tyson who has had charge of it since 1881. It was operated by other parties for several years previous to that date. The stone occurs in irregular layers with many vertical seams, especially numerous near the outcrop, thus dividing the stone into small dimensions. (See No. 1, Plate 21).

The stone has a light gray color, and coarse texture, merging into conglomerate in many places, with a few intercalary streaks of shale. It occurs in irregular layers six inches to three feet thick, the entire thickness of stone shown on the present face aggregating 45 to 50 feet, overlain by 20 to 30 feet of red shale and three to twelve feet of yellow sand and sandstone, the red shale containing thin layers of hard sandstone. The quarry, in fact none of the quarries here were in operation at the time of my visit, Oct. 19, 1896. It is said to employ 20 to 30 men and ships most of the stone to Philadelphia for use in foundations.

About 250 yards above, N. W. of, Tyson's quarry is another fully as large, said to belong to Mr. Schenlein and operated until recently by Mr. John Brown. It is in layers which overlie those in the Tyson quarry. It contains more and coarser conglomerate than Tyson's quarry, some of the pebbles being as large as hen's eggs, and in some places so feebly cemented that they drop out on the exposure of the rocks, giving the face of the quarry a pitted appearance.

About 100 yards northwest from the Schenlein quarry is another quarry said to have been opened by Mr. Brown after he left the Schenlein quarry. The stone is somewhat similar to that in the last quarry, but more uniform in color and texture, having much less conglomerate. Some nice brownstone could be obtained here along with much that is pebbly. The microscope shows the stone to be made up of large angular quartz and feldspar grains, the feldspar consisting of both the alkali and basic feldspar, the latter predominating. There are a few small mica scales and considerable clay and granular quartz. See No. 2 on Plate 21.

Brown's quarry.

Tyson's quarry,

Views in the brownstone quarries near Norristown, Pa. Showing structure and depth of weathering.

Fort Washington.- About half a mile above Fort Washington station on the Philadelphia and Reading railroad, on the east side of the railroad, are two quarries of very light colored brownstone, so light in color as to be more properly termed gray. They are in strata in the New Red formation which contains the true brownstone quarries. So that it is put here more on account of its geologic relations than because of the color.

The stone is coarse-grained, made up of grains of white quartz and white and pink feldspar, with some associated mica.

In the larger of the two quarries which is owned by Mr. Kennedy and worked by Mr. Burl, the stone is 30 to 35 feet thick, overlain by 3 to 6 feet of sand and boulders. There are many weather seams cutting the stone into small dimensions. In a few places blocks as large as 3 to 4 feet across are obtainable, but the greater part of it is in small dimensions, so far as can be judged by the quarry face.

The stone has been used locally for building. The handsome residence of Mr. Kennedy and probably not less than a dozen other houses in the vicinity, and a number of buildings at Ambler, are constructed wholly or in large part, of stone from these quarries. (See No. 2 Plate 20).

The smaller quarry known as Wallace's quarry is not now (1896) in operation.

Doylestown.- There are several quarries of local importance in the vicinity of Doylestown, and in a number of places stone has been gathered from the surface for use in bridges and farm buildings.

The largest quarry so far as known in the vicinity is that run by Joseph Paul at Frog Hollow, near Neshaminy postoffice, six miles south of Doylestown, on the Philadelphia pike. The opening covers an area of about an acre, 20 to 25 feet deep, having 15 to 20 feet of comparatively sound rock, overlain by two to four feet of red sand, shelly stone and soil. The strata dip, 10 to 12 degrees to the north. There are two marked systems of joints, one north-south, one east-west, from one to four feet apart. Nearly all the stone can be moved from its position in the bed by wedging or by the use of a bar. Powder is used to some extent for breaking up the larger blocks.

The stone has a rather dark brown color, spotted in places, with iron rust. It is very fine grained, finer than the average brownstone. There are a few feldspar grains mixed with the quartz, nearly all the grains having a thin coat of red hematite which also occurs in grains scattered through the rock.

The quarry was opened, it is said, not less than 50 years ago. Mr. Paul has had charge of it for 20 years. He employs from two to four men, and the product of the quarry is all used locally, the nearest railway points being Doylestown on the north and Willow Grove on the south, each six miles away. The almshouse hospital, about four miles north of the quarry, is said to be constructed of this stone.

Stone has been quarried for cellar walls and road metal below the stone bridge at Edison postoffice, a mile and a half south of Doylestown, but none of it is suitable for dimension stone.

The stone arch bridge across Neshaminy creek at this point (Edison postoffice) is made of native stone, but inquiry could not locate the spot more closely than that it was made of stone picked up on the adjoining hills. It was constructed in 1800, many years before the railroad was built, and it is in a remarkably good state of preservation, no signs of decay noticeable anywhere on the bridge. It speaks well for the durability of the stone. (See Plate III, No. 1.)

A. P. Loux, Tradesville, Pa., has opened a quarry on his farm, two miles south of Doylestown, where stone has been taken out in small quantities for local usage. The Jewish school building now (October, 1896) being erected, one-half mile northwest of the quarry, is of stone from this quarry. There are several small openings, none of which have penetrated more than 15 or 20 feet and consequently not beneath the weathering influences, the numerous weather seams cutting the rock into small dimensions. The rock has a light gray color, with a brownish tint. The surface along all of the seams has a dark brown stain. There are a few spots of conglomerate, but much of it has an even medium coarse grain, the grains composed of quartz and feldspar, the quartz grains interlocking in places; there is some interstitial clay and granular quartz.

Grenoble.— There is a quarry of very light colored brownstone on the east side of the Philadelphia and Reading railroad, close to the track, about two hundred yards south of Grenoble station, Bucks county. It has been operated by Moody & Edwards since October, 1895. It was not in operation in 1894, and had been worked by Mr. Ryan, of Philadelphia, during 1892-93 and Jameson & Ryan in 1891.

There is about 22 feet of fairly sound stone, overlain by three to eight feet of shelly rock, largely waste, three to six feet of red sand and shale, and one to four feet of yellow sand. The rock is cut up by numerous seams, so that most of the stone comes out in small dimensions, made still smaller by the liberal use of powder in quarrying. A large part of the product goes for cellar walls, rubble work and similar uses. Some large dimension stone is obtained. The color is a very light brown, the grain finer than the average, and in a few places it is slightly cross-grained, but not to any great extent. It is made up of a closely aggregated mass of quartz and feldspar, the latter much decayed, considerable hematite coating the quartz and feldspar and in grains diffused through the rock.

The company employs from 12 to 22 men in the quarry and ships stone to different places in Pennsylvania and New Jersey—at present (October, 1896) they are filling an order for Camden, New Jersey.

The railway station at Grenoble, a neat, little brownstone structure, is made of stone from this quarry, which is also used in a number of schoolhouses in the surrounding country.

There is a small abandoned opening on the north bluff of the Neshaminy creek, half a mile west of Grenoble station, where the rock is darker colored than that on the railroad and very shelly where exposed. It is overlain by a heavy bed of red shale.

Along the railway north of Grenoble station and half a mile south of Rushland station, there are large exposures of red shale, 50 to 75 feet thick, but no rock of commercial importance.

North and Northeast of Rushland station are exposures of black shale, weathering rusty brown on exposure. It is quarried about a quarter of a mile north of Rushland and crushed for road material.

C. Northeast end of the New Red Brownstone Area.

Newtown, Yardley, Carversville and Lumberville.

Newtown.—There is but one quarry at Newtown that produces building stone; that is operated by Mr. Mitchell, who has had charge of it for 14 years, and who operated the Yardley quarry for the nine years preceding.

The quarry is nearly two miles west of Newtown and nearly two and one-half miles from the railroad. The stone that is shipped by rail it is necessary to haul this distance. However, much of the stone delivered within a radius of 10 to 14 miles is wagoned the entire distance, as it is thought to be cheaper than the extra handling in the haul at each end of the road. Stone is hauled by wagon to Trenton, N. J., 10 miles away.

As might be judged from the shipping facilities, the stone is largely cut-stone of good quality, as there would be no profit with low priced stone with such expensive transportation.

The stone is somewhat similar in character to the Yardley stone, but has a lighter, brighter, more uniform color and more even grain than much of the Yardley stone.

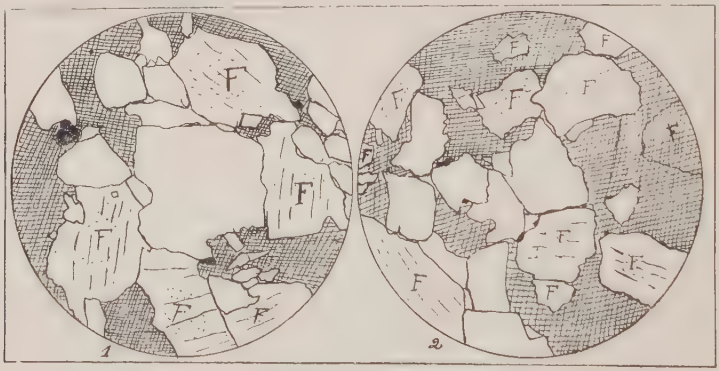
The color is a light brown, with a purple tinge, and comparatively uniform. It has a medium fine grain and fairly uniform texture throughout. There are a few bands toward the bottom, two to four inches thick, which contain shale fragments sometimes in sufficient quantities to give the stone a darker color, and in all cases injuring the quality of the stone. It is slightly cross-grained in a few places, but the great mass of the stone is fairly uniform.

It is more feldspathic than the stone further west as shown both by the chemical and microscopical examination.

Chemical analysis of Newtown brownstone.

Silica (SiO_2),	82.34
Alumina (Al_2O_3),	11.46
Iron oxide Fe_2O_3),	1.07
Lime (CaO),	.27
Magnesia (MgO),	.19
Manganese oxide (MnO_2),	.07
Potash (K_2O),	.17
Soda (Na_2O),	3.76
Water (H_2O),	.80
Total,	100.13
Specific gravity,	2.66

The decreased percentage of silica and the increase of alumina and soda indicate an increased percentage of feldspar or feldspathic material over the Hummelstown stone, which fact is shown the more clearly in the mieroscopic section (Fig. 5), which, when compared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small wedges. Across the grain it is split by drilling holes, six to twenty inches deep, depending on the size of the block to be split, and driving in wedges.

There is a thickness of 35 feet of solid stone, overlain by 35 feet of shaly sandstone, red shale and yellow sand at the west end, thinning to one or two feet at the east end. It all lies above water level on the north bluff of the Neshaminy creek.

The strata dip N. 10 degrees, E. 12 to 15 degrees, so that the stripping increases rapidly in working back into the hill. An admirable economic feature of the stone is the joint seams. There are two systems, one N. 10 E., one N. 90 E., which are very regular, with smooth faces and from four to twenty feet apart, thus subdividing the bed into roughly rectangular blocks of different sizes. By having a face of considerable extent, Mr. Mitchell finds it easy to split off blocks of any required dimension from some point along the face with very little waste by selecting the block of the proper width. The jointing is shown on the accompanying view of the quarry, figure 6.

Fig. 6.—Mitchell's Quarry, Newtown, Pa., showing thickness of layers, system of jointing and amount of stripping.

The stone has been used extensively for trimmings for both stone and brick buildings and a number of buildings are constructed of it entirely. It is a stone easily carved and looks well either on rock face or tool dressed.

Some of the buildings in which it has been used are the German Hospital, Philadelphia; Convent of the Good Shepherd, Chew street, Germantown; Episcopal Hospital, Germantown; the First National Bank, Presbyterian and Methodist churches, addition to the public school building, and a number of handsome private residences in Newtown.

Watson's quarry.—There is a small quarry about half a mile south of the village of Newtown operated by Mr. Charles Watson, which produces crushed stone for macadamizing roads. A steam rock crusher was put in two years ago, but has not been in constant operation. The stone has a dark brown color, is hard and brittle and contains much more iron oxide than that at Mitchell's quarry.

There is about fifteen feet of brownstone overlain by three to five feet of soil and red shale. The strata dip 10 degrees N., 20 degrees W., with numerous seams east-west and north-south. None of this stone is used for building except a very little for cellar walls.

The brownstone outcrops in several places in the vicinity of Newtown, in places of very similar character to that in Mitchell's quarry. The approximate line of these outcrops is shown on the Bucks-Montgomery county maps made by Dr. Lyman.*

The creek in the town flows over a solid bed of brownstone, which shows in the bottom of the creek.

The stone is exposed in a number of places along the road between Mitchell's quarry and the town, also on the Doylestown road, northwest of the town. About one and one-half miles northwest of the town on the Doylestown road, the outcrop shows several feet of the sandstone in a massive ledge, where a good, workable stone would likely be found close to the surface. In most places the stone is quite shelly on the outcrop.

Yardley.—There are several grades of stone and a number of small quarry openings in the vicinity of Yardley. Two of the largest quarries, known as the Yardley and Nicholson quarries, are in stone similar in their general character, and resembling somewhat the Newtown stone.

The stone in these two quarries is a light brown, rather coarse grained soft sandstone, much softer than the Lumberville stone; in fact, softer than almost any of the other brownstones in the State.

The shipping facilities are rather defective, most of the stone being

*See maps accompanying the New Red of Bucks and Montgomery counties, Volume 3, part 2, of the Summary Final Report, Pennsylvania Geological Survey, 1895.

sent by canal, some of it by rail on the Philadelphia and Reading railroad, but neither of the quarries is on the canal or the railroad. The Yardley quarry is about 200 yards from the canal and a mile or more from the railroad. The Nicholson quarry is nearly a half mile from the canal and more than a half mile from the railroad. This is the principal reason, probably, why these quarries are not worked more extensively. Another reason given by some of the quarrymen is that the lease rate is too high.

The Nicholson quarry, one-half mile north of west of the village was first worked probably 100 years or more ago, but previous to the war the work was on a small scale. About 1868 it began to be worked more extensively. In 1873 the Twining Brothers obtained control of it and ran it for about nine years, during which time a great deal of good building stone was taken out. They employed from 25 to 50 men. In the last year or two of their work much of the stone went into bridges, but in previous years it went largely for buildings in Philadelphia and Camden. Mr. Twining says he remembers furnishing stone for at least ten school houses in one year in Philadelphia.

The quarry was operated by Mr. Shevlin for several years after the Twining Brothers left it, but it has been idle now for several years, except occasionally stone is removed in small quantities by different parties for local use.

The quarry opening covers about three acres in extent, 30 to 50 feet deep. A variable thickness of three to fifteen feet at the top consists largely of red brown shale with some interstratified shelly sandstone, with 25 to 35 feet of light purplish brownstone underneath.

The stone is evenly bedded and in the bottom heavily bedded, but one or two bedding seams showing in the 20 to 25 feet from the bottom. There are two sets of joint seams, one N. 20 degrees E. one N. 70 degrees W., the first one being more pronounced. These seams are two to twenty feet apart, thus cutting the stone ino rectangular blocks of varying sizes.

The bottom of the quarry is not perfectly level. Near the southwest corner there is quite a prominence on the quarry floor where the stone dips in various directions.

The color is fairly uniform, being a light purplish gray, in all places being darker on the face of the stone and along the joints than in the interior. This is probably due in large measure to the sediment washed from the overlying red shale by the rains. The stone is soft and works easily. The microscope shows a greater percentage of quartz than that in the Yardley quarry and the feldspar better preserved.

The Yardley quarry is about a half mile north of Yardley and about 200 yards west of the canal, thus having an advantage over

the Nicholson quarry in transportation facilities by water. The quarry was worked for a number of years by Mr. Mitchell, who is now running the Newtown quarry, but is now operated by Mr. James Shevlin, who has had charge of it for eight years. Much of the stone is used for rubble work in Camden and Philadelphia, yet considerable cut stone has been shipped. Some of the buildings in which the stone has been used are a Catholic church at Camden, an addition to the public school building at Camden, Presbyterian church at Easton, wing of the Episcopal Hospital, Front and Lehigh avenues, Philadelphia, and the Doylestown Court House in part. (See list on p. 39.)

The opening is 5 or 6 acres in extent, 30 to 45 feet deep. The stone is weathered to considerable extent, having 3 to 5 feet of yellow soil on top, underlain in turn by 3 to 10 feet of red shale and shaly sandstone and 6 to 8 feet of sandstone with many weather seams and 20 to 25 feet of good stone with seams in numerous places. Much of the stone is in small dimensions which goes largely for rubble work, along with which considerable good dimension stone is obtained. The nicest stone exposed at the present time is in a north wing of the quarry, at the east end where, near the bottom of the quarry, a light pink colored rock occurs that has a very attractive appearance. There is a little quartz conglomerate mixed with it, but not in sufficient quantities to cause much waste. The opening is nearly filled with water, work at the present (Sept., 1896) being carried on at the west end of the quarry, so that the extent of this bright colored stone could not be observed.

The upper part, in places more than half of the stone, can be removed by simply prying it loose from the bed with bars inserted in the seams. In the lower part of the bed where the seams are fewer and not so open powder is used to blast the stone loose.

*Chemical analysis of brownstone from the Yardley quarry.**

Silica (SiO^2),	82.72
Alumina (Al^2O^3),	10.29
Ferric oxide (Fe^2O^3),	1.92
Lime (CaO),	.17
Magnesia (MgO),	.36
Manganese oxide (MnO^2),	.16
Potash (K^2O),	.10
Soda (Na^2O),	2.92
Water (H^2O),	1.22
Total,	99.84
Specific gravity,	2.675

*Made in the Chemical laboratory of Pennsylvania State College.

The microscope shows the feldspar to be much decayed in places, only a trace of the original in the resulting clay cement remaining along with numerous fine grains of quartz diffused through the clay and a few small spots of segregated iron oxide in the clay and coating the grains. (See the right side of No. 2 in Fig. 5 on p. 80). The stone is not uniform in texture, having small areas quite quartzose made up of interlocking quartz grains while other areas of equal extent have comparatively no quartz.

There is another quarry about two miles north of Yardley, on the bank of the canal, worked by Mr. William White. The stone is hard red and black shale and slate, no sandstone occurring at this point. It is used for rip rap along the river, no dimension stone being quarried. There is aface of 50 to 60 feet showing:

Soil and shelly rock,.....	6 in. to 1 foot
Shelly, weathered rock,.....	1 in. to 3 feet
Solid red shale, with many seams,.....	6 in. to 8 feet
Brown shale, with streaks of green,....	10 in. to 15 feet
Solid red shale,.....	10 feet
Greenish blue shale,.....	0 in. to 12 feet
Blue-black calcareous shale,.....	10 feet

There are several quarry openings along the canal south of Yardley that were not visited by the writer. The stone is said to be of inferior quality, used only for cellar walls and rough work and the quarries have not been operated for several years. They are in layers that underlie those in the quarries above mentioned. In several places in the vicinity of Yardley, north and northwest of the town are outcrops of brownstone similar to that in the quarries.

The lack of proper transportation facilities prohibits further exploitation. With sufficient capital to build a railway to the quarries, the present ones might be operated more extensively and others opened. The thickness of the bed is not great, but in proportion to the amount of waste, the quantity is equal to that in many quarries worked with profit farther from good markets than these.

Carversville.—The Carversville quarry was not visited by the writer. It was purchased by the Twining Brothers, of Yardley, and operated for them by Mr. Edwards, now at Grenoble, from 1881 to 1885. It was purchased by them primarily in order to get light colored stone to fill a contract in Philadelphia, where the darker colored Yardley stone could not be used. Stone was taken out for various school houses and churches, but the hard stripping, and difficulty in keeping out the water and the distance from the railroad and the canal all combined to make the further working of the quarry unprofitable.

Lumberville. — The Lumberville stone, advertised by one company as the Lumberville granite, while not very brown occurs in the New Red formation, closely associated with brownstone and interstratified with red shales.

The manager of one of the quarries says they call the stone granite for the want of a better name. The stone-cutters refuse to work it as sandstone, and they were compelled to use some other name. The stone is properly a quartzite or a quartzitic sandstone, but there is so little quartzite used in the trade that the term is not a familiar one among dealers, and so was not used. It is an unfortunate use of the much abused term granite.

Dr. Penrose calls it a "feldspathic quartzite," an appropriate name for the geologist, but still more difficult to introduce into the stone trade than simply quartzite, as feldspar is not a familiar term to many of them.

Mr. Paxson, another of the quarrymen, calls it graystone, a legitimate if not a very definite term.

From the standpoint of the stone-cutter or the merchant there is some excuse for classing it as a granite, as it is not greatly different from an average granite in composition, either chemical or mineralogical, being made up of the detritus from granite rocks, but the basic minerals have decayed to a large extent. It takes granite tools to cut it, being harder than any sandstone.

In its origin or mode of formation it is a sandstone, being composed of granular sedimentary material hardened into rock. It differs from the ordinary sandstone in having the grains more firmly cemented, which causes the greater hardness and differs from ordinary quartzite or quartzitic sandstone in having more foreign material along with the quartz.

In its history it differs from the common sandstone in that a large proportion of its constituents are derived by erosion from fresh granite or granitic rock of some kind, while ordinarily the sand sediment is derived from decayed rocks in which the feldspathic and other complex minerals are broken up and the quartz separated from the other materials. The rock needs to be fused and recrystallized to form granite. Hence, while the term is probably permissible from the stone-cutter's standpoint, it is to be deplored from a scientific point of view.

According to Dr. Lyman's classification, it comes in the same division of the New Red as the Yardley and Newtown quarries, called by him the Norristown shales; but the Lumberville stone is at a somewhat lower horizon than the others, corresponding more nearly with the gray stone along the canal south of Yardley.

The stone is essentially different in hardness as well as color from any others anywhere in the New Red formation in the State, so far as

known to the writer. That at Raven Rock and Stockton, N. J., on the other side of the river near by rather closely resembles it, but is not so hard.

It differs from the average brownstone not only in color, but noticeably so in hardness. The prevailing color is a blue gray, with a faint pink tinge, more pronounced in long exposed surfaces, with light brown in places, in some places buff, and in others various shades of gray and blue; and some layers a decided brown. It is only by quarrying on a large quarry face on a large scale and selecting the stone, that a stone of uniform shade of color can be obtained.

The variation in texture is equally as great. It varies from fine-grained to a coarse conglomerate, the conglomerate occurring in thin bands or layers, varying from a fraction of an inch to a foot or more in thickness in the finer grained stone with rarely any line of parting between them. The pebbles are quite variable in composition, some being nearly pure quartz, some feldspathic, and many of a dark red brown shale, so abundant in places as to give the stone a decided dark color.

A partial chemical analysis shows a percentage of silica of 79.58 per cent. with iron oxide, lime and alumina present.

Its extreme hardness is shown (1) by its crushing strength, which is more than 20,000 pounds to the square inch, about four times that of an average sandstone; (2) by the impact test (Johnson), which gave a loss of but .46 per cent.; (3) its absorption, which is 1.12 per cent.; (4) and decidedly the difficulty met in cutting it. The stone-cutters refuse to work it for sandstone, turning it over to the granite cutters.

The hardness is due in part (1), to the interlocking of the angular grains; (2), the presence of some quartz cement binding the grains, and (3), the presence of calcite in the cement, as shown on the accompanying micro-drawing, the one to the left being an exceptionally feldspathic area, the one to the right showing the calcite cement.

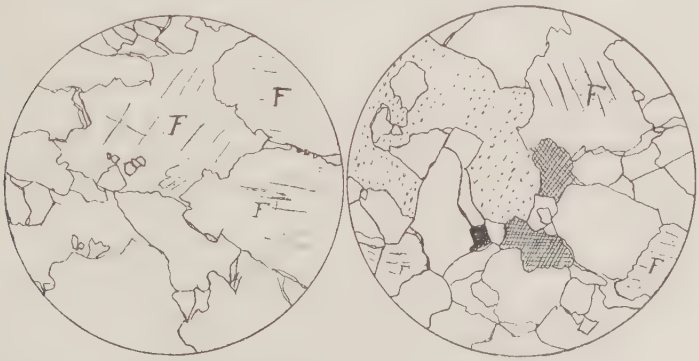


Fig. 7.—Micro-drawings of the Lumberville stone. F is feldspar, the clear areas quartz, the cross-lined areas clay and granular quartz, the dotted area calcite. Magnified 44 diameters.

The stone occurs in heavy bedded, in places almost massive, layers, having a dip west of north. Weathering opens incipient bedding planes, so that near the outcrop the stone occurs in thin layers, but in the interior, beneath the action of the weather, the bedding seams are almost entirely absent, the thin layers merging into a massive bed so far as the bedding planes are concerned. However, there is a system of nearly vertical joints (back seams) running in a nearly southwest-northeast direction at varying distances apart, from a few inches to four or five feet. The cross joints, or wall seams, at right angles to these, are in most places very few, frequently 20 feet or more apart, in consequence the stone on the outcrop is generally cut up by the different seams into small dimensions, which increase in size beneath the surface and in the lower part of the deeper quarries it occurs in blocks as large as can be handled. (See Plate 23.)

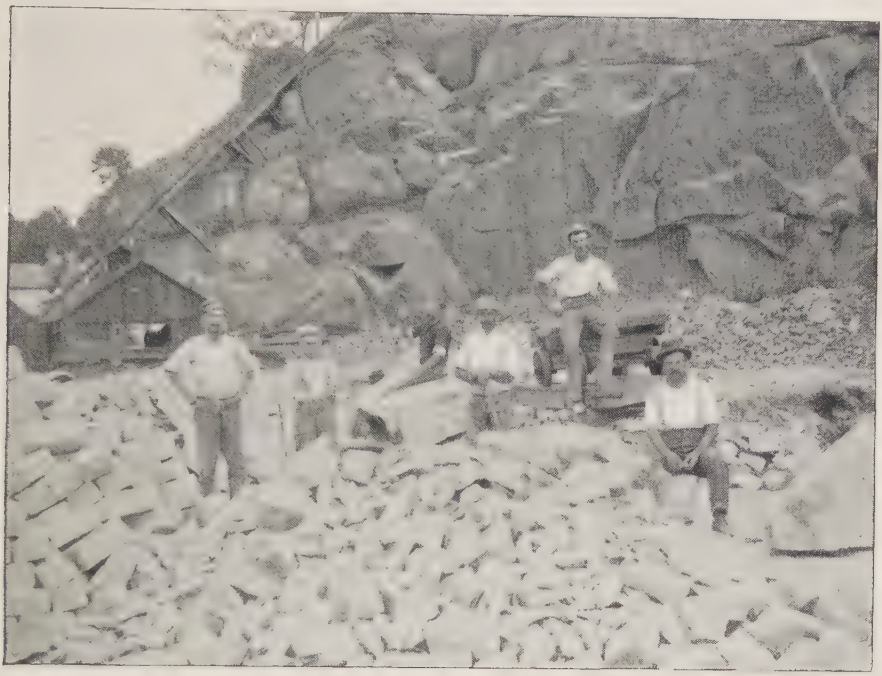
The total thickness of the stone at this locality is not known, but must be several hundred feet. The quarries are all in different layers, the dip of the rock being 12 to 13 degrees N. 35 degrees W. (varying in different places), the lowest (most easterly) quarries being in the lowest layers, the quarries farthest west being the highest in the series.

While the joint seams are quite regular and uniform in direction, there is in many places a thickness of an inch or more along the joint surface that is quite scaly. While the material in these separate thin scales or layers is very hard and firm the rock is rendered shelly for an inch or two along the seam by these small joint planes paralleling the larger ones.

The grain of the stone is remarkably straight, which largely compensates for the excessive hardness in the quarrying of the stone. To split large blocks it is only necessary to put in a few shallow drill holes, and drive in wedges to produce a break remarkably straight and even.

The quarrying of the stone is made very simple and comparatively easy by utilizing the joint seams. These seams vary a few degrees from the vertical and after getting an opening made to the required depth it is only necessary to throw down these nearly vertical layers one after the other. This may be done sometimes by merely prying them loose with a bar, while sometimes a small charge of powder is used. In some of the openings they work under the leaning layers, thus utilizing the gravity of the stone and greatly economizing the force necessary to move the blocks. In some of the lesser openings they work from the other side, which necessitates a much greater force to move the stone.

The crushing strength of the stone is very much higher than any of the commoner sandstones as may be seen on consulting the table



1. At right angles to the plane of the joints.

2. In the line of the joints.

Views in the Lumberville quarries, showing the joint structure.

on page 30. Four specimens, tested at Fairbank's laboratory in New York City, gave the following results in pounds per square inch: No. 1, 20,180 pounds; No. 2, 21,080 pounds; No. 3, 21,780 pounds; No. 4, 16,540 pounds making an average of 19,895 pounds per square inch for the four. However, two of the specimens (Nos. 2 and 4) had been subjected to freezing tests before crushing, and taking the two fresh specimens (Nos. 1 and 3) the average would be 20,980.

Two samples tested in Philadelphia in the laboratory of Booth, Garrett and Blair, August, 1896, gave an average of 24,625 pounds per square inch.

Tests on the shearing stress made by Prof. Garrison, of the Franklin Institute, gave for four specimens the following result: No. 1, 6,990 pounds per square inch; No. 2, 2,370; No. 3, 5,560; No. 4, 6,360, giving an average of 5,320 pounds per square inch.

Absorption tests made on two specimens after immersion for twenty-four hours gave 1.04 per cent. and 1.11 per cent., an average of 1.07 per cent.*

The stone has a specific gravity of 2.595, weighing 162 pounds per cubic foot.

All the above tests were made on samples from the quarries of the Lumberville Granite Company, and published in their circular.

They show a stone of hardness and strength, about the same as the Laurel Run and White Haven red stone.

The Lumberville stone has been used extensively in Philadelphia for Belgian blocks in paving along the street car lines. Its hardness makes it stand the wear remarkably well, the granularity prevents it from growing slippery and the straight grain assists in the splitting of the stone into proper dimensions.

Experience appears to sustain the results indicated by the foregoing tests. L. M. Haupt, civil engineer (Company's Circular), says that he has examined the pavement on Chestnut street, Philadelphia, Pennsylvania, that has been down about eight years and subject to the heavy traffic of that business street and finds no appreciable signs of wear, many of the blocks showing the original quarry marks.

The making and shipping of these blocks have been carried on quite extensively at this place.

It has been used to some extent for building in different places, St. John's College, Brooklyn; Mr. Rodenbaugh's house, Easton, and Mr. Robert Wright's home in Allentown, being some of the buildings constructed of it. Others are enumerated in the table on p. 39.

The stone is nearly all shipped by boat on the Delaware division of the Lehigh canal, which is a ready means of transportation to Phila-

*Made in the department of tests, Stevens Institute of Technology, at Hoboken, New Jersey.

delphia, Camden and intermediate points along the Delaware valley, as well as towns up the Lehigh valley.The Lumberville Granite Company has fitted up a wire cable way across the river to the Belvidere division of the Pennsylvania railroad, by means of which stone can be delivered on the cars with great rapidity.

There are six or more openings, all located along the banks of the canal on the west (south) side of the Delaware river.

The two upper, most westerly, openings belong to the Lumberville Granite Company, which is the largest producer in this locality. The upper opening, which is now abandoned, has 50 or 60 feet of stone exposed, and in one place an opening of considerable extent below the quarry floor, now filled with water. There are numerous seams in a northeast-southwest direction, cutting the stone into rather small dimensions. There is a bed of shale overlying the sandstone, and one lenticular streak of shale in the body of the stone.

The next opening, which is being worked at the present time, is separated from the first mentioned by a wall 30 to 40 feet thick, called by the operator the "Ragged Edge," consisting of stone much seamed and broken. The hill is much higher at this point hence a much greater thickness of the stone is worked. It is said to be 135 feet at the highest point of the quarry face. The seams are further apart than in the other opening, hence the stone occurs in larger dimensions. There is a lens-shaped mass of red shale in one place in the quarry face and on another place an irregular mass of dark colored shale. The rock varies considerably in texture, having streaks of conglomerate interspersed with fine grained stone. By having a large quarry face and taking the stone out in large quantities it is possible to select material uniform in grain and color. Much of the stone has been used as paving blocks.

The next quarry, the first one below the grist mill, belongs to W. F. Paxson. It occurs in strata lying underneath those in the quarries above mentioned. The hill is not so abrupt at this point and the quarry face not so high, being 40 to 50 feet. There is about 30 feet of purplish gray stone at the base, overlain by 6 to 10 feet of red shale, followed by a constantly increased thickness of light colored shelly sandstone with many seams. As in the other quarries, the stone is not uniform throughout, having streaks of conglomerate and shale, but the greater part of the bed is stone of good quality. Plate 23 gives a view in this quarry showing its proximity to the canal and facilities for loading and shipping. Much of the stone from Paxson's quarry is used for building.

The next two openings toward the east were made by Thomas Conner, of Centre Bridge. He furnished some cut stone for Fairmount Park, Philadelphia, but all the remainder of the stone from his quar-

Paxson's Quarry, Lumberton, Pa., Showing structure of the stone and facilities for loading and shipping.

ries was used for common rubble masonry, shipped by boat and sold by the perch in Philadelphia and Camden. The stone is somewhat similar to that in the quarries above mentioned, but there is a much heavier stripping and more shale and conglomerate mixed in the stone.

The next two openings to the east are said to have been made by J. M. Samsell, of Mt. Pleasant. The face of the quarry shows from 50 to 80 feet of stone, 3 to 20 feet of weathered shelly material at the top. The upper half of the quarry contains many more seams than the lower half, due to the weathering influences.

There is said to be a small quarry above Lumberville which produces crushed stone. There are several quarries on the New Jersey side of the river at Raven Rock and Stockton. (Described later under the head of New Jersey.)

D. The Mauch Chunk Red Stone.

The Mauch Chunk red shale or the "red shale," as it is frequently called throughout the eastern part of the State, occurs in the Lower Carboniferous rocks, immediately underneath the heavy beds of Pottsville conglomerate which forms the base of the Coal Measures. While it is largely composed of a bright red shale, in many localities, notably along the eastern borders of the area, there is a great deal of hard red and brown quartzitic sandstone, and conglomerate.

The red quartzite or quartzitic sandstone is as brown and in that sense as much of a brownstone as that in the New Red or Mesozoic age. It differs greatly, however, in its physical character from much of the brownstone in the markets, but it must be remembered that there are great variations in the brownstone of the New Red formation. So far as the economic use of the stone is concerned this is as much a brownstone as though it came from the rocks of Mesozoic age.

Na m The stone is very hard as compared with sandstone, as already stated. So hard is it that one of the quarries markets it as red "granite;" another does not go quite so far, but calls it simply "red stone." There is the same reason for using the term granite instead of sandstone here as at Lumberville, namely that the sandstone cutters refuse to cut the stone, saying emphatically that it is not sandstone and the ordinary sandstone tools will not cut it. While it is more easily broken and chipped than granite, it is probably as hard to cut and finish, and takes similar tools. As agreements for cutting and dressing the stone must be made on a granite

basis, it naturally follows that it takes the name granite which is exceedingly unfortunate as the nomenclature of building stones is sufficiently confusing already. The stone is properly a quartzite or quartzitic sandstone, terms while not common in the market are not unknown, or difficult of interpretation, and the use of them will avoid widening the use of the word granite which already includes (in the stone market) a great many varieties of rock.

Description.— Like all quartzites, it is very hard compared with common sandstone. Quartzite differs from common sandstone in having a greater proportion of siliceous cement, which being harder than the clay or iron oxide cement, binds the grains of sand more firmly together. It may grade imperceptibly from the friable sandstone on the one hand into compact quartz in which the original grains are no longer perceptible on the other. The quartzite of the Mauch Chunk formation shows the separate grains quite distinctly, but they are very firmly bound together and there is nothing friable or crumbling about it. In some cases the hardness is due to a carbonate, presumably calcite, cement which appears in considerable quantities in the microscopic examination. The stone is not quite so hard as the Sioux Falls, Dakota, quartzite, much used in the western markets, and apparently about equal in hardness to the Potsdam stone from Potsdam, New York. Its hardness is indicated by its great crushing strength which surpasses that of many of the granites.

The stone is distinctly stratified occurring in layers from a few inches to several feet in thickness. In most places the upper layers and face of the stone at the outcrop are in thin layers which in almost every instance thicken towards the interior of the bed. In some places the thin layers extend to a greater depth than in other localities close by, and are in all cases the result of the weathering influences opening the incipient bedding seams. As these thin layers make excellent flagstone they are a desirable feature much sought after.

In many places the rock contains false bedding quite pronounced, but unlike false bedding in many rocks, it is so regular and even that for quarrying purposes it takes the place of true bedding and in several places the parting seams in the flagstone are on the false bedding planes which are as regular and produce as nice flags as the true bedding, but naturally have more waste in working them. (See Fig. 1, p. 17.)

The color is various shades of red, but with the exception of a faint banding in many places it is generally uniform at any one locality. It is in general lighter and brighter than the average brownstone, although it has a deep brownish red color in places. The faint banding is very common, the bands running with the grain or bed of the rock, which is sometimes with the true bedding of the rock, but in many places with the false bedding.

Chemical composition of the Mauch Chunk Red Stone — The stone is very highly siliceous, having a higher percentage of silica than the average sandstone and about equal to the average quartzite, as may be seen by comparing the analyses in the table on page 13. The two analyses given below are the only ones that have been made as far as could be ascertained. The first, made at Cornell University, N. Y., is of the Laurel Run Red Stone, from the quarry managed at the time by Gen. P. A. Oliver, now worked by J. A. Schmitt. The other is the White Haven stone, "Red Granite," from Mr. Daneker's quarries, made in the Crane Iron Company's laboratory:

Analysis of the Laurel Run Red Stone.

Silica (SiO^2),	94.00
Iron oxide (Fe^2O^3),	1.98
Lime (CaO),	1.10
Magnesia (MgO),	1.00
Volatile matter, water and carbonic acid,	1.92
Alumina and manganese,	
Total,	100.00

Analysis of red quartzite ("red granite") from John A. Daneker's quarry, White Haven, Pennsylvania.

Silica (SiO^2),	90.360
Protoxide of iron (FeO),*	1.147
Alumina (Al^2O^3),	2.173
Metallic iron (Fe),	.803
Lime (CaO),	2.
Magnesia (MgO),	Trace.

Physical tests: weight, absorption and strength†— The stone has a specific gravity of 2.656, equal to a weight of 166 pounds per cubic foot. This represents an average of 25 samples, which range from 2.586 (the only one below 2.6), the lowest to 2.723, the highest, 20 of the 25 being between 2.6 and 2.7, one below 2.6 and four above 2.7.

The ratio of absorption after immersion in water 20 days is less than one per cent. For the stone in its natural condition the rate is .11 per cent., for artificially dried stone it is .365 per cent., which is far below the average of sandstone.

Tests on the Laurel Run Red stone at Cornell on 12 two-inch cubes gave an average crushing strength of 17,640 pounds per square inch ranging from 14,200, the lowest, to 23,600, the highest. One three-inch cube, and two four-inch cubes were not broken under a pressure of 50,000 pounds.

*So given in the copy of the analysis, apparently a mistake for peroxide, as indicated both by percentage of metallic iron and the red color of the stone.

†Data under this head almost entirely from tests made at Cornell University.

Thus it will be noticed by comparing with other stones on page 30, that this is much higher than any of the common sandstones and much like that for quartzites and quartzitic sandstones.

Its transverse strength in which this stone surpasses all common sandstones, and which is a necessary property in such positions as sills, lintels, facings and steps, is shown in the following tests made at Cornell, on the Laurel Run Red Stone.

Deflection test on Laurel Run Red Stone.

No.	200 lbs.	400	600	800	1,000	1,200	1,400	1,600
2	0.015	0.025	0.033	0.042	0.063	0.073	0.088	Broken.

No.	900	1,100	1,300	1,500	1,700	1,900	2,100	2,500
3	0.010	0.022	0.046	0.052	0.066	0.072	0.098	0.148

No.	2,700	2,900	3,100	3,700	3,900	4,100	4,300	Broken.
3	0.156	0.160	0.208	0.276	0.294	0.312	0.306	

Shearing test on Laurel Run Red Stone.

Block 2.00 x 2.00 □, in double shear over area of 4.5 sq. in.

Load, . .	500	1,000	1,500	2,000	2,500	3,000	3 500
Def., . . .	0.48	.078	.100	.114	.132	.156	.188

Load, . .	4,000	4,500	5,000	5,500	6,000	6,500	7,000	7,500
Def., . .	.198	.214	.232	.240	.256	.276	.286	.304

Frost test on Laurel Run Red Stone.

(Test by hot immersion.)

No.	Weight cold.	Weight after immersion.	Loss in weight.	Per cent.
1	131.826	131.670	0.156	0.12
2	145.649	145.515	0.154	0.11
3	118.348	118.002	0.346	0.29
4	144.360	143.985	0.375	0.26

Frost test on Laurel Run Red Stone.

(Test by Brard's Method.)

No.	Weight in air.	Weight dried 1 day.	Weight dried 3 days.	Loss.	Per cent.
1	125.748	125.831	125 670	0.018	0 06
2	96.314	96.371	96.165	0.149	0.15

NOTE.—In the test by hot immersion, Nos. 3 and 4 had been previously saturated with water, so that the test was especially severe and represented a maximum effect.

Absorption tests on Laurel Run Red Stone.

No.	Weight in air.	Weight wet.	After one day.	Two days.	Twenty days.	Loss.	Per cent.
1. . .	106.224	106.283	106 512	106.485	106.596	0.313	.29
2. . .	123.296	123.370	123.836	123.874	124.173	0.808	.65
3. . .	144.281	144.376	144 614	144.640	144.670	0.294	.21
4. . .	126 883	126 946	127.226	127 291	127 341	0.395	.31
5. . .	136 294	136.376	136.475	136.465	136.520	0 144	.10
6. . .	94 580	94.650	94.686	94 765	94.740	0 090	.09
7. . .	118.600	118.480	118.660	118.690	118.675	0.195	.16
8. . .	114.590	114.655	114 792	114 832	114.813	0.128	.11

NOTE. Nos. 1, 2, 3 and 4 were artificially dried before testing. Nos. 5, 6, 7 and 8 were just as received.

Compression tests on Laurel Run Red Stone.

Number.	Deflect at 0 lbs.	1,000 lbs.	2,000 lbs.	3,000 lbs.	5,000 lbs
13.	0 000	. . . . .	. . . . .	0 003	0.011
15.	0.000	0 051	. . . . .	0 051	0.029

Number.	10.000	15,000	20.000	25,000	30,000	35,000	40,000	45,000	50.000
13	0.028	0 020	0.020	0.034	0.013	0.011	0.026	0.019	0 028
15.	0 021	0.047	0.055	0 065	0.069	0.055	0.045	0 057	0 075

Crushing tests on Laurel Run Red Stone.

Number.	Area.	Crushing load.	Load per square inch.	Remarks.
1.	2.20	44 500	20,200	Bedded in wood.
2.	2.12	35.400	16,700	" plaster.
3.	2.07	33,300	16.000	" "
4.	1.99	47.500	23.600	" "
5.	2.22	37.000	16.700	" "
6.	2.10	35 000	17.000	" "
7.	2.22	31.000	14.200	" "
8.	2 25	40.000	15,500	" "
9.	2.25	48.600	21,500	" "
10.	2 22	34.000	15.000	" "
11.	2.25	47.500	21.000	Broken along bed.
12.	2 25	32.500	14.400	Broken along bed.
13.	4.45	50.000	. . . . .	Not broken.
14.	4.20	50.000	. . . . .	Not broken.
15.	3.43	50,000	. . . . .	Not broken.

Mean = 17640 lbs. per sq in.

Flexure tests on Laurel Run Red Stone.

Number.	Area of section.	Between supports.	Breaking load
1, ...	2 03 (b) x 1.50 (h)	7 inch.	1 600 lbs.
2.	1.99 x 1 47	7 inch	1,400 lbs.
3.	2.06 x 2.05	5 inch.	4,500 lbs.

In the assay laboratory at State College several samples from the Laurel Run and the White Haven quarries were tested in the furnace to ascertain their fire-resisting properties. They were first heated to 700 degrees Fah. then 1,150 degrees and then 1,600 degrees and some even higher. Some were cooled in air and some thrown in

cold water. Only one of the specimens was cracked, the others showing no injury in the texture, but those at the high temperature, 1,600, changed color perceptibly, the rather bright red turning to a pale, brownish red, the tests proving that if not absolutely fire proof the stone stands the fire remarkably well, and is entitled to rank among the fire proof stones.

Microscopic character of the Mauch Chunk Red Stone.—The accompanying figure (fig. 8) shows some of the different types of tex-

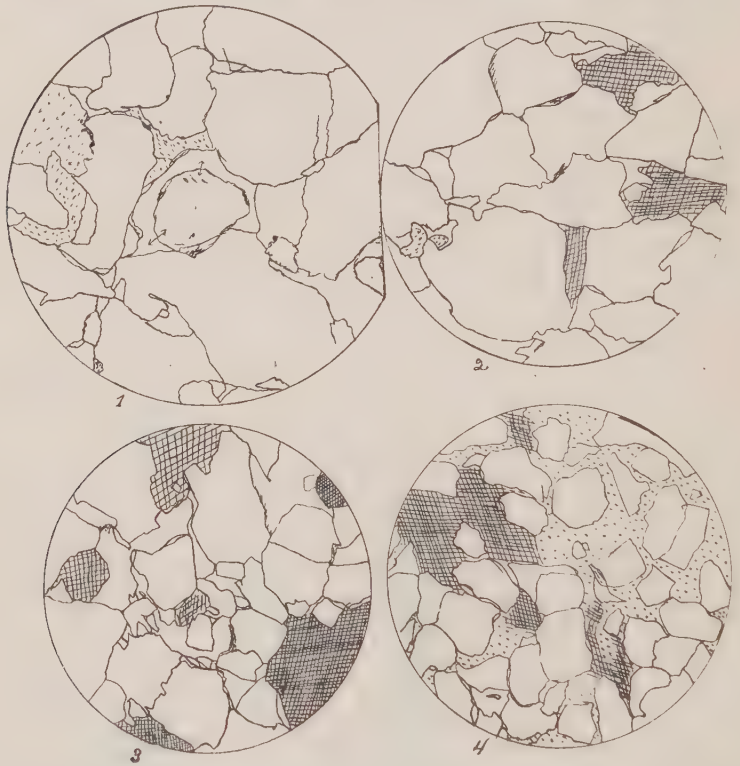


Fig. 8.—Micro-drawings—enlarged 44 diameters—of the Mauch Chunk red stone. Cross-lined areas clay with finely granular quartz, dotted areas calcite, clear areas quartz. Typical quartzite grain in middle No. 1. No. 4, an exceptional calcareous area. All show the interlocking of the quartz grains.

ture taken from rocks of different quarries, but the texture is by no means uniform at any one locality or at any one quarry, or in fact in a single specimen, (See also No. 2 on Plate 1.) No. 1 on figure 8 is from the Laurel Run quarries and shows a typical quartzite grain in the midst of the section, with an old sand grain in the interior surrounded by secondary quartz oriented with the enclosed grain. Secondary quartz is shown elsewhere in the figure and the dotted areas are carbonate (presumably calcite) cement, which makes a rock nearly as hard as the quartz cement. No. 2 is from the same quarry and shows some clay in the interstices possibly from feldspar decay-

ed in place. No. 3 is from Daneker's White Haven quarries and shows a greater percentage of clay, but still retaining the quartzite character by the interlocking of the quartz grains with secondary quartz. No. 4 is from Cooper's quarry and shows the predominance of the calcite cement making really a calcareous sandstone. However, similar calcareous areas may be found in the sections from the other quarries.

Durability.—The stone if properly selected is one of the most durable ones in the State. This is indicated by 1. The chemical analysis which shows it to be nearly all quartz, one of the most durable of minerals. 2. Its texture, which is close-grained, compact, and almost wholly non-absorbant. 3. The outcrops which frequently form bold ledges, even hills of prominence through the region in which it occurs. 4. The glacial boulders which over this area are in many places nearly all this red quartzite and almost invariably have a hard, smooth surface with no evidence of disintegration after their hard freezing and many centuries of exposure.

Artificial tests made in the Cornell laboratory as shown on the preceding pages, also indicate great durability; four samples in the hot immersion test, showing a loss less than a quarter of one per cent. 0.12, 0.11, 0.29 and 0.26 respectively. Brard's frost test showed a loss even less two samples giving 0.06 and 0.15 per cent.

Uses and adaptability.—The stone has been used for buildings, both facings and trimmings, pavements both foot and street, for bridges, retaining walls and foundations. The flagging forms an important part of the product and is much sought after. A large part of the product goes into Belgian blocks for paving streets. It is said to be superior to granite in this respect.

It is not a first class stone for all varieties of building work. Its great hardness does not adapt it to any class of work that requires much cutting or dressing. However, it is claimed by workmen that this difficulty disappears in part with familiarity with the stone.* The even regular bedding and the ease with which the stone can be chipped, along with the smooth compact texture and pleasing color adapt it to rock-faced ashlar, either coursed or uncoursed. It is superior to many other building stones in having such a hard close texture that dust and vegetation do not disfigure it. The hard,

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Wilkesbarre, Pa., April 4th, 1890.

*In all my experience as a stone-cutter, I have not met with a stone so hard as the Laurel Run Red Stone, that I can manage as easily as I can the Laurel Run Red Stone. A man unacquainted with the stone will say, on first attempt to cut it, that it is an unpleasant stone to cut. This impression will, after a few days or weeks experience be changed, and he will notice that after his days work is done, he is not so tired as he was when he cut the soft sand stones or granite. It requires a peculiar manipulation of the tools, and when once acquired, it is not hard work. I like to cut Red Stone, I have been cutting it for seven years or more.

Yours truly,
JAMES TEMPLETON.

rather glassy appearance of the stone is against its universal use as a building stone even though it could be easily wrought. Some of the accompanying illustrations show the architectural appearance of the stone. While not an ideal building stone, it is a very good one, and will likely be used in considerable quantities for that purpose. It will never have an extensive use because of the opposition from the stone-cutters.

It is best adapted to street work and should be used more extensively for that purpose. It is admirably adapted to this work for curbing, crossings, Belgian blocks, flagging or crushed stone. It furnishes an almost ideal flag stone where it occurs in thin sheets, being hard, strong, and not breaking easily, and would practically never wear out or wear as smooth as limestone or granite, nor is it so readily soiled or discolored as a lighter colored stone. For Belgian blocks it is eminently suited, being very hard, yet easily chipped into shape, does not wear rapidly or wear smooth.

Methods of quarrying.—The work throughout the area is largely done by hand. Holes are drilled by hand and charged with powder, blasting off large blocks of the stone, which are broken up with heavy hammers and trimmed with hand hammers into Belgian blocks of standard size or cut by hand into the proper form for curbing or dimension stone. Most of the derricks are of hand power, only a few horse power and but one steam power, although Mr. Dancker at White Haven is daily (Sept., '96) expecting steam hoist and steam drill. He also contemplates a saw mill to be run by water power to saw the stone into shape. The steam drill and steam hoist are used in the Laurel Run quarries in connection with the Knox blasting system.

Distribution.—The distribution of the Mauch Chunk formation in the State is shown in part on the accompanying map (frontispiece.) Besides the area on the map this formation has quite an extended linear out crop through the north-central and the southwest part of the State, but so far as known to the writer there is, with probably one exception, no sandstone or quartzite of commercial value in this part of the area. In fact in only a small part of the area shown is the quartzite known to occur, as the greater part of the formation is of red shale. So far as known the only places it has been quarried are Mocanaqua; the Elbow, near Mt. Park, Wilkes-Barre; Laurel Run; and along the Lehigh valley from two miles or more above White Haven to Hickory Creek several miles below White Haven. A quarry near Rockwood, Somerset county, Pa., may be in this formation.

Local details of the Mauch Chunk Red Stone.

White Haven.—While the red quartzite occurs abundantly in the village of White Haven, the regular quarries of the stone are some distance from the town, both south and north, in the Lehigh valley.

Reiser and Doland's quarry.

Cooper's flagstone quarry.

Quarries in the Mauch Chunk red formation along the Lehigh river below White Haven.

The largest producing quarries are about two miles north of the town and belong to John Daneker, who has quarried stone here since 1873. For 17 years he wagoned the product to White Haven and shipped from there by railroad. In 1890, he constructed a short branch railway from the Lehigh Valley railroad to one of his quarries, and later from the Central Railroad of New Jersey to the other, and can now ship by rail direct from his quarries by either railroad. He shipped more stone in 1890, the first year he had the railway in the quarry, than in all the previous years together. Heretofore the work has been done by hand, but a steam drill and a steam hoist has been ordered and daily expected (September, 1896), after which the stone can be handled more rapidly and presumably will be worked more extensively. He contemplates adding a saw mill, to be run by water power on the creek that passes the quarry. It is very doubtful if a stone as hard as this can be sawed with profit.

The work so far has been largely surface work, none of the openings penetrating to any depth, but scattered over a large area. They may be divided into two groups, one group being scattered along the west bank of the Lehigh river, and another along the east bank of a small creek nearly a mile from the river. Plate 25 shows views in these quarries. The ones on the creek bluff have been worked more extensively than the others. There were apparently at one time a number of openings along the low bluff, but they are now nearly all connected into a continuous opening, several hundred yards in length.

The workable stone varies in thickness from 15 to 30 feet along this bluff. The quality of the stone is superior towards the west end, where the covering is also the heaviest. The inferior quality of the stone towards the east end has caused that end to be abandoned.

Much of the flagstone has the parting on the cross-bedding. The layers vary somewhat in character in different places. What is good stone in one place is too shelly and seamy in another part of the layer to be valuable. In most places the stone is sufficiently thin bedded for flagging near the surface, the bedding planes disappearing away from the outcrop toward the interior of the bed. This is probably the chief reason why so much of the work both here and elsewhere is confined to the surface, as the heavy bedded and massive stone is very hard to work by hand.

In some places the good marketable stone appears at the surface, while in other places it is covered with glacial boulders, sand and gravel, to a depth varying from a few inches to three or four feet. Frequently from two to six feet at the top of the bed will be shelly or "wild" and thrown out with the waste, but in some places the shelly stone is wholly lacking.

The quarries on the river show a much greater thickness of stone

than the other quarries, but they have been more recently opened, and have not been worked so extensively. In no single opening was a thickness greater than 50 feet observed, but the different openings are on different layers, so that the total thickness shown is probably 200 feet or more, with more or less intercalary shale. The strata dip to the north about 10 degrees, so that the underlying layers are met in going south along the railway track. Underneath the stone in the most southern opening is a heavy bed of red shale, which contains conglomerate in places, and north of the upper opening hard stone outcrops in the overlying layers at least as far as the bend of the river, a half mile or more above.

A section of the face at the north opening shows:

4 to 6 feet of glacial material, sand and boulders.

20 feet of red stone, free from bands, nearly uniform in color.

30 feet of faintly striped or banded red stone; some cross grain.

5 feet red shale.

Near the south end a section shows:

10 feet weathered shaly red quartzite.

12 feet red quartzite with numerous seams.

18 feet clean solid red quartzite, with remarkably smooth joint seams.

12 feet solid red quartzite.

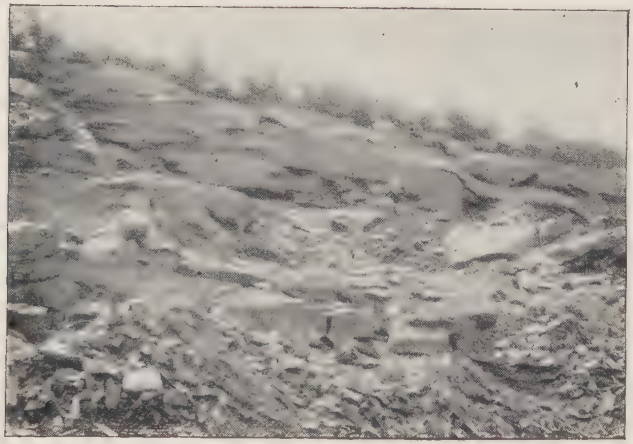
8 inches striped quartzite, red gray and dark bands.

The striped layers at the base appear to be a gradation between shale and the quartzite, and while the freshly exposed stone in the quarry appears to be quite hard and firm, it is not liable to prove as durable as the single colored stone.

Near the south end of the ledge there are great numbers of clear quartz crystals, which form a thick coating along the seams. Most of these crystals are small, but some are a half inch or more in diameter. They are almost as clear as those from Herkiomer county, N. Y. So far as observed by the writer, this is the only locality in the Mauch Chunk area where the quartz crystals occur in any considerable number.

There is a vast quantity of this red stone available both in these openings along the river and in the other openings described above, and everything suggests that the stone industry here is but in its infancy. While good building stone is available it is probable that it will always be secondary to the production of Belgian blocks, flagging, curbing and broken stone work. The working of the stone is greatly facilitated by the even parallel joint seams. Mr. Daneker is now filling a large order for paving blocks to Elmira, N. Y.

John Redington and Company's quarry.—Redington & Company's quarry is a half mile below White Haven, near the top of the hill on the east side of the Lehigh river, near the Lehigh Valley railroad,



View of portion of the creek quarry looking south.

View of portion of the creek quarry looking southeast.

View in the river quarry.

View in the river quarry

and a short distance north of Tannery station. The quarry has a face of 25 to 35 feet of red quartzite, overlain by a few feet of glacial material and underlain by red shale. In places there is a thickness of a few inches to two or three feet of loose shelly rock at the top, while at other places the rock is sound to the top. There is considerable cross grain running in different directions in different parts of the bed.

Some flagstone has been obtained near the surface, but none in the interior of the bed where the layers are heavier. Nearly all the product of the quarry is used for Belgian blocks. At the present time (October, 1896), they are shipping blocks to Wilkes-Barre on an order for fifty car loads.

The quarry has been operated by this company for about two years and was run by other parties in a desultory way for about six years previously. The company is not doing a large business, but apparently a profitable one. The quarry is kept clean and in good shape.

On the west side of the river opposite Redington & Co's. quarry, is a quarry opening, now idle, said to belong in part to Mr. Fox and in part to Mr. Kennedy.

Cooper Brother's quarry.—The Cooper Brothers' quarry is on the west side of the Lehigh river, below the Tannery. Unlike the other quarries, it is not on a bluff, but on the nearly level top of the hill, about one-fourth mile back from the river and the railroad.

The top of the hill is nearly level and the strata are here nearly horizontal. The hill has been planed off by the glaciers, glacial striae showing in a number of places bearing South 5 degrees West. There is in most places a thin coating of glacial material, varying from a few inches to a few feet in thickness, consisting of sand and a great many slabs of the red quartzite overlying the red stone in place.

This is more distinctly a flagstone quarry than any of the others in the vicinity, and the product of the quarry is almost entirely flagstone. The bottom view in Plate 24 shows the flagstone character of the stone. The stone has been worked to a depth of about 12 feet, and comes out in small regular flags from two to six inches thick. In some places near the surface the flags are separate, and it is only necessary to pry them up and break them into the required dimensions; in other places the seams are not open, and it is necessary to wedge the slabs loose from the bed. Mr. Cooper says they have raised flags from 25 to 35 feet long, but most of it is in smaller dimensions. Some of the slabs show faint ripple marks. The quarry has been operated by the Cooper Brothers since 1892, and while operated on a small scale, the product has been increasing each year since the quarry started.

In a shallow ravine about 100 yards south of the flagstone quarry,

there is a solid ledge of the quartzite exposed from 20 to 30 feet thick, from which they have quarried some stone; more of the work done here, however, has been on the boulders which have broken loose from the ledge. Some of this stone is of a deeper red than the flagstone.

Reiser and Doland's quarry.—Still further down the Lehigh Valley, below Penn Haven Junction, on the Central Railroad of New Jersey, is another red stone quarry operated by Reiser & Doland, of Wilkes-Barre. The product of the quarry has been increasing in value since it was first opened in 1894.

The product of this quarry is about evenly divided between flagstone and building stone, no blocks having been made so far. The stone is nearly all shipped to Wilkes-Barre where it is used for pavements, steps, platforms, trimmings for brick buildings, foundations and retaining walls.

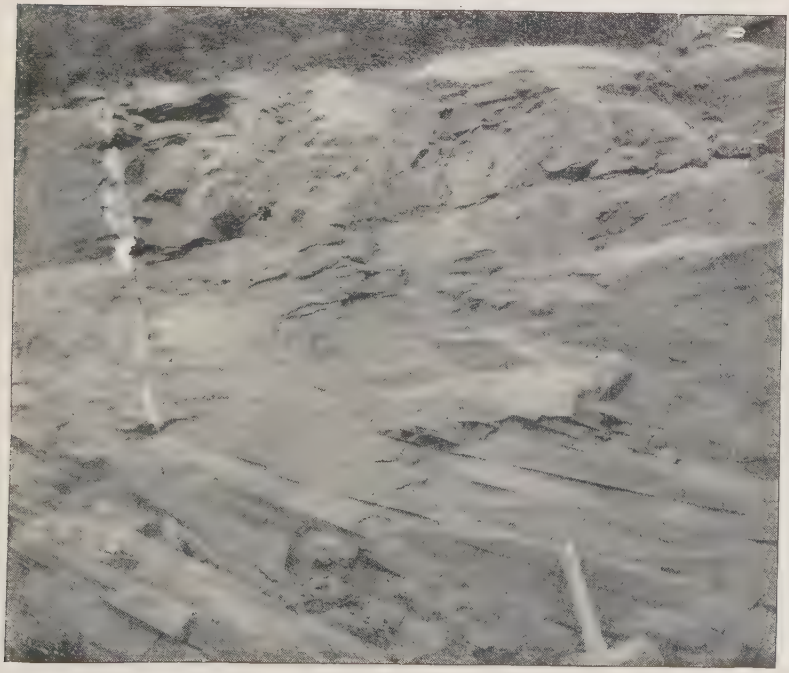
The face of the quarry runs nearly north and south, and parallel with and along the outcropping ledges of the strata, with dip N. 10 to 15 degrees. The thickness of the stone worked is about 15 to 20 feet. In the present opening there is more flagstone at the south end where the work is nearer the outcrop, in places the flagstones being only two or three inches thick, and at the north end where the opening is deeper, the rock is heavier bedded, and for the most part a quite uniform chocolate color, almost free from the banding so common in many places. Shelly quartzite and shale outcrop in large quantities underneath the bed worked in the quarry. The upper view on Plate 24 is taken from near the south end of the quarry, looking north and down along the face of the quarry with Lehigh river in the distance.

Laurel Run Red Stone quarries.—The Laurel Run Red Stone quarries are at Oliver's Mills on the Central Railroad of New Jersey, about ten miles south of Wilkes-Barre. The quarries are along the ridge on the northwest side of Laurel Run, a branch from the railroad extending into the quarries 300 yards or more. The stone has been quarried along the face of the bluff for nearly a half mile. The northeast end belonging to General Oliver runs in a northeast direction, and is now worked by John Schmitt, of Wilkes-Barre. The southwest end running S. 75 W., and belonging to the Hollenbach Coal Company and the Lehigh and Wilkes-Barre Coal Company, is not operated at present.

The stone belongs to the Mauch Chunk red formation, and is quite similar in its general character to the stone at White Haven. The tests given on page 94 are on stone from Olixer's quarries.

The dip of the strata is northwest or into the hill, so that the thickness of the stripping increases rapidly as the stone is worked back into the hill, which accounts for the great length of the quarry and

Quarry face in John Schmitt's quarry.



Part of face in Oliver's quarry showing the cross bedding.

Views in the Laurel Run red stone quarries. Showing structural features.

the narrowness of it because as soon as the thickness of the stripping is thought to be too great to be removed with profit, operations are suspended in that direction and extended laterally. The thickness of the layers quarried is about 20 to 25 feet. The overlying material consists of a softer, crumbling rock overlain in turn by glacial debris and the underlying rock is concealed by debris.

The true bedding of the rock is very faint, scarcely discernible in some places, but the false bedding is in most places rather pronounced, shown generally by a banding along the false bedding planes, and in some places a cleavage or parting on the false bedding, some flagstone being formed in that way. The false bedding in most places is inclined east of north, but in a few places it dips in different directions, as shown on the accompanying photograph Plate 26, and drawing in Fig. 1, page 17.

Flagstone occurs in nearly all places on the outcrop, the effect of exposure apparently being to open the bedding (in most instances false-bedding) planes. As the stone is quarried back from the outcrop, the seams become less numerous and finally disappear, and the stone becomes solid and apparently harder. It is very difficult to drill and cut, but where the grain is straight it works to fairly good advantage, as it splits straight and easily. When the stone is massive and cross-grained, it is quite difficult to work, as the fracture is liable to branch off on the false bedding in unexpected places.

Most of the stone quarried here is used for building purposes in Wilkes-Barre, some of the finer buildings constructed of it being the St. Nicholas German Catholic church (see Plate 4), First Presbyterian church, Baptist Chapel and numerous residences. (See list on page 40.) It has been used in large quantities for foundations and retaining walls in Wilkes-Barre. Some stone was shipped to Philadelphia by General Oliver, but the venture did not prove profitable, and was not repeated. Much of the broken stone and waste is crushed with a steam rock crusher and used for concrete. The capacity of the crusher is about six car loads per day. The stone is admirably adapted for this purpose, the particles being so hard that they will resist wear where subject to it, and are equally proof against attack by acids and corroding agencies.

The stone will no doubt continue to have a limited use for building purposes, but it will never be extensive, because of the difficulty in dressing it, and the opposition from the stone-cutters. It is well adapted to rock-face ashlar in combination with other building stones. No more durable stone could be obtained for bridge piers. Its hardness and durability make it an admirable stone for flagging, curbing and paving. The points in favor of its more extended use

are 1, great durability; 2, its great strength; 3, its beautiful color; 4, large and small dimensions; 5, convenient to the railway. While its disadvantages are 1, hardness; 2, cross-grain; 3, heavy stripping; 4, limited dumping ground because of the railway running along the side of the steep hill just below the quarry.

The Elbow.—At the Elbow on the Central Railroad of New Jersey, between Laurel Run and Mt. Park, considerable red stone has been quarried, but the quarries are not now in operation. There is one opening on the lower (east) side of the railroad on a steep hillside overlooking the creek. The strata dip from 12 to 20 degrees west of north, thus crossing the track. There has been very little rock removed from the upper side of the railway on account of there being no dumping ground, and the loose rock in quarrying rolling on the track and interfering with railway travel. The thickness of the stone quarried varies from 15 to 25 feet, with about the same thickness of stripping. There has been some flagstone and some heavier stone removed which shows considerable cross-bedding in places. No particulars are at hand as to the length of time this quarry was open, or of the use made of the stone.

Across the ravine about 150 yards east of the Elbow there is another opening in the Mauch Chunk red quartzite that has been worked over an area of about 20 or 25 yards square, with a maximum depth of about 30 feet. There is a thickness of about 10 to 20 feet, from which nice flagstone two to four inches thick was obtained, the beds of the flagging being faintly ripple marked in places. The upper part of the rock exposed at the opening is full of seams and cracks, and is useless as building stone. Part of that in the lower part of the bed is much cross-grained and cannot be worked to advantage, so that there is a great deal of waste.

There is another small opening, belonging to Mr. Parsons about 100 yards east of the one last mentioned which has been worked by hand on a small scale for a year or more. A hand derrick has recently been put up and flagstone is being removed.

The red quartzite outcrops in many other places in the mountains south of Wilkes-Barre, but so far as could be ascertained it is not worked at any other point. Mr. Joseph Hendler who has a large conglomerate quarry about two miles east of the Elbow, claims to have a very promising outcrop of red quartzite easily accessible by railroad.

Mocanaqua —A half mile above Mocanaqua Station, on the Pennsylvania railroad, opposite Shickshinny, is a quarry in the Mauch Chunk red quartzite that is idle at present. It is on the south side of the north branch of the Susquehanna river, close to the railroad—

too close in fact, as it leaves no room for a dump. The hill is here very steep, capped with the coarse Pottsville conglomerate, and the quartzite forms a bold outcrop, but not in the most desirable positions for quarrying, as the steep bluff prevents working any but the surface stone, and the railroad and river along the base interfere with dumping the waste material. The stone varies greatly in character, thus a layer that is good, solid flagstone in one place will be quite shaly or be part of a massive ledge only a few yards away. Near the east end of the quarry opening a section shows 25 feet of rather massive quartzite, but shelly on the surface, underlain by 10 to 12 feet of solid massive quartzite, underlain by 12 feet of banded quartzite, that furnishes flagstones on the outcrop.

Good stone in sufficient quantities for local usage could be obtained here at moderate expense. While the stone is very hard and in heavy layers the greater part of it has an easy cleavage parallel with the bedding. Local workmen state that the stone is not difficult to work.

In the vicinity of Mocanaqua, Wilkes-Barre and elsewhere throughout the anthracite coal region the hard, massive, Pottsville conglomerate has been quarried for use in bridge piers and other heavy masonry.

PART III. BROWNSTONE IN THE UNITED STATES OUTSIDE OF PENNSYLVANIA.

Pennsylvania has a larger area of the New Red formation than any other one of the eastern states, and probably has as many or more brownstone quarries, but most of the openings are small, of only local importance, and it is not the leading state in the value of brownstone produced.

In the total value of sandstones produced Pennsylvania ranks second in the Union, Ohio standing far in the lead. But brownstones while forming a considerable part do not include all the sandstones of the State. There is much gray and buff stone in the western and central portions. Connecticut, with but four quarries, ranks first in the production of brownstone, having the oldest and largest brownstone quarries in the United States. The brownstone product of New Jersey is probably nearly equal to that of Pennsylvania.

The output of New York, Wisconsin and Michigan forms an important part of the total product.

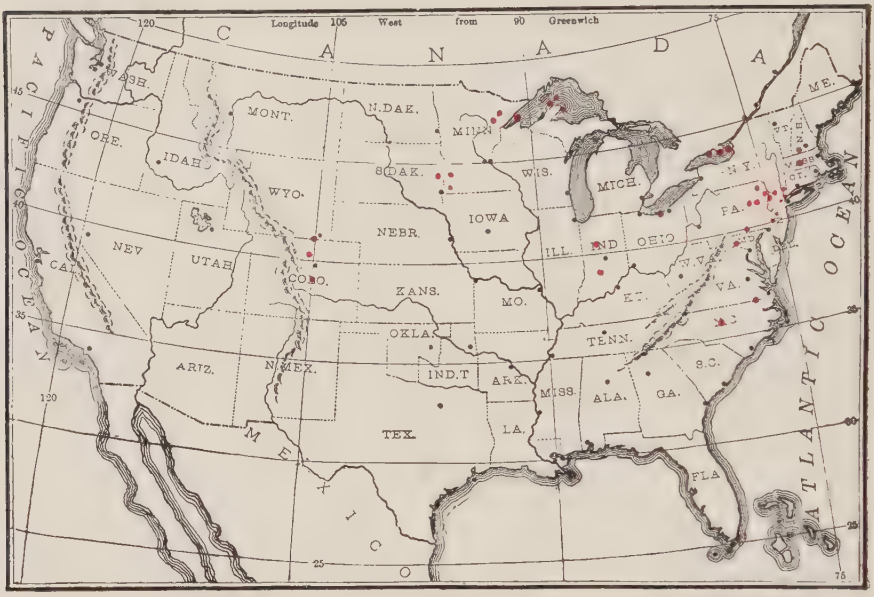


Fig. 9.—Showing location of brownstone quarries in the United States.

As the stone from these different quarries meet in competition in the markets, it is thought advisable to give a brief description of them in this report.*

Colorado.

Several shades of brownstone said to be of good quality and well adapted to building purposes occur at different points in Colorado in the "Red Beds" (Lower Trias).

Quarries have been opened at Manitou, Bellevue, Stout Arkins, and Lyons, but no particulars are at hand as to whether any of these are or are not in operation at present.†

Connecticut.

The brownstone quarries at Portland, Connecticut, are the oldest, largest and best known quarries in the United States. So extensive has been the use of this stone that in many places the terms brownstone, Portland and Connecticut stone have been used as synonymous terms.

*The Connecticut quarries, many of the New Jersey and the Ohio ones, and all of the Indiana quarries, have been visited by the writer; the descriptions of the others have been obtained by personal correspondence and interviews with the quarrymen, dealers and others, and from census reports and such other sources of information as could be found. The States are arranged in order alphabetically.

†A brief description of the above localities is given by Merrill in "Stones for Building and Decoration," New York, 1895.

The miles of brownstone fronts in New York and other eastern cities attest its architectural value and beauty. The many scaling and disintegrating fronts equally well illustrate its misuse.

The oldest and largest quarries are at Portland on the east bank of the Connecticut river, opposite Middletown, and near the center of the state, where stone has been quarried for 200 years or more. The oldest authentic record of the operation of these quarries is a mention of them in the record of the town council at Middletown, 1665. So far as known they have been operated continuously since that date.

In 1852 a quarry was opened at Cromwell, on the west side of the river, two miles above Portland, and another in 1886, both of which are now in active operation.

The stone at both places is regularly stratified, the strata having a gentle dip of a few degrees to the west. The separate beds have a thickness varying from a few inches to ten or twelve feet, in a few places much more.

The entire thickness of the stone is not known, but it is known to be more than 500 feet in one place. The Middlesex Quarry Company quarried to a depth of 200 feet and drilled with a core drill 312 feet more, giving a total of 512 feet, without any perceptible change in the character of the rock. How much deeper it is, is not known. None of the openings are more than 250 feet in depth, the companies finding it more profitable to strip a new area than to quarry deeper than that. Dana, in his manual of geology, states that an artesian boring was carried down 4,000 feet at New Haven through porous sandstone.

The stone varies slightly in color and considerably in texture. Layers of good, fine-grained brownstone alternate with layers of coarse conglomerate, fine conglomerate and streaks of shale. The conglomerate is not limited to any one part of the quarry, but is more abundant towards the top than at the bottom. Much of the coarse stone goes into the waste, but that with smaller pebbles is sold as second and third class stone. More than half the stone is thrown out as waste.

The analyses of the stone show it to be less highly siliceous than many other sandstones, and from the standpoint of durability alone a lower percentage of alumina might be desired, in so far as it absorbs moisture, thus hastening decay in the scaling, cracking and disintegration. This is partly balanced by the fact that clay is a much softer cement than silica, and hence the stone is more easily cut and dressed.

Analyses of Connecticut Brownstone.

	Portland.	Cromwell.
Silica (SiO^2),	70.11	70.84
Alumina ($A1^2O^3$),	13.49	13.15
Iron oxide (Fe^2O^3),	4.85	2.48
Lime (CaO),	2.39	3.09
Magnesia (MgO),	1.44	Trace.
Potash (K^2O),		3.30
Soda (Na^2O),	7.37	5.43
Loss,		1.01
Total,	100.00	100.00

Mineralogically it is made up of quartz, feldspar and mica—granitic detritus. The mica is present throughout the bed, occurring even in the coarse conglomerate, but more abundantly in the thinly laminated part of the bed. The stone has a dark brown color, remarkably uniform throughout all the quarries.

There are now three companies at Portland. The Brainard Company and the Shaler and Hall Company combined this year into the Brainard, Shaler & Hall Company, which operates all the quarries formerly run by the two companies. The Shaler and Hall Company has been in existence since 1788, owning the lower or south quarry at Portland. The Brainard Company started in 1812, under the name of E. and S. Brainard, changing to E. and S. Brainard & Company, later to Brainard & Company, and finally in 1879 to the Brainard Quarry Company, which it remained until the change above noted this year.

The Middlesex Quarry Company was organized in 1841 by the union of the Patten and Russell and the original Shaler and Hall quarry. They operate the upper or north opening which covers about 30 acres, and is worked in several different places.

The other company at Portland is the Connecticut Steam Brown Stone Company, which has no quarry, but operates a large steam mill where stone from the other quarries is cut and dressed for position in the building before shipping. This was established in 1884, and one wonders on seeing the large amount of stone that annually passes through this mill, why such a mill was not operated there long before that time.

There are three companies at Cromwell, and as at Portland two quarry companies and one mill company. The Connecticut Free Stone Quarry Company opened its quarry in 1852, and with the exception of 16 years, when it was leased to the Portland quarries, it has been in operation ever since.

The New England Brownstone Company has been in operation since 1886, and has done an extensive business.

The Middlesex Steam Brownstone Company has a mill on the premises of the New England Brownstone Company, in which the stone is prepared for its place in the buildings. The stone at Cromwell is very similar to that at Portland in character. There is a heavier bed of glacial material overlying it, and as far as one can judge from a hasty inspection of the quarry walls, there is more waste than in the Portland quarries.

The quarries, yards and mills at both Portland and Cromwell are equipped with modern machinery and appliances. The drilling is done almost entirely with steam drills and the steam channeler is used to some extent, but the presence of numerous bedding seams enables them to loosen the stone much more cheaply with the Knox blasting system, which is used in all the quarries. The channelers are used for cutting out corners, cross cutting at the ends, etc.

Formerly the stone was dragged from the quarry to the boat landing by oxen, at one time as many as 200 cattle being in use for this purpose. Steam has almost entirely replaced the cattle, two yoke at the Cromwell quarry being all there are in use at the present time (October, 1896). The stone is now lifted from the bottom of the quarry with steam hoists on large cranes and placed on the railroad car, frequently 200 feet or more above the quarry floor. The edge of the quarry is studded with these large cranes, capable of lifting a car load of stone in a few minutes. There are several large locomotive cranes moving on the track about the yards loading and unloading stone. There is a railway switch from the New York, New Haven and Hartford railroad to each of the quarries, and the Cromwell quarries also have connection with the New England railroad, but the greater part of the stone is shipped by boat on the Connecticut river from docks near each of the quarries.

Prices of the Connecticut brownstone ranged from 50 cents per cubic foot in 1844 to $1.26 in 1874, and has since dropped until at the present time the price is 95 cents for first class brownstone. The prices for second grade and inferior stone is much lower. The annual production of stone of the first quality during prosperous years varies from 850,000 to 1,000,000 cubic feet; of the coarser, cheaper grades, about twice that amount is produced. During the last two years the value of the output has been below $400,000 annually.

The Connecticut brownstone has been extensively used in all the eastern cities, especially those along the seaboard, New York naturally being the largest consumer, where some of the most elegant residences and public buildings are constructed of it. In smaller quantities it has been shipped all over the United States and even to Canada. Senator Flood's mansion, on Nob Hill, in San Francisco,

is of stone from the Middlesex quarry, which was first sent by boat to Newark, where it was dressed and crated, reloaded and shipped by way of Cape Horn to San Francisco.

For many years these quarries were excessively prosperous, and with from 1,200 to 1,500 men at work, could not fill all the orders, but the financial dullness of the country and other causes have changed this condition, and they are now in active competition with other quarries for orders. Not only has the opening of many new quarries elsewhere lessened the trade, but the facilities for handling the stone have improved so that there is scarcely any limit to the amount of stone that could be put out on demand.*

Indiana.†

Brownstone occurs in several localities in the Carboniferous sandstones of western Indiana. The stone has been quarried at Mansfield, Hillsboro, Greenhill, Judson, Portland Mills, Bloomfield and St. Anthony, but the only quarries now in active operation are those at St. Anthony.‡

Two defects found in the stone are lack of uniformity and the occurrence of iron blisters. While these injure much otherwise good stone, it nevertheless remains that there is a great deal of excellent brownstone not yet quarried in the vicinity of Mansfield, Bloomfield and St. Anthony. J. B. Lyne & Son operate a well equipped quarry at the latter place, having switch connection with the Louisville, Evansville and St. Louis railroad.

Quarries have been worked to considerable extent at Mansfield and Hillsboro, the latter on the Cleveland, Cincinnati, Chicago and St. Louis railroad (Big Four), and the former connected by short line with the Big Four at Carbon and the Vandalia line at Brazil. A quarry was opened at Portland Mills in 1895 from which a railway is contemplated to the Indianopolis, Decatur and Western Railroad, six miles distant.

The Indiana Brownstone is soft, especially when first quarried, and is not fit for paving or any use where subject to abrasion, but is well

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*References:

1. The Middletown Tribune, Middletown, Connecticut, Souvenir edition, 1896, by H. F. Donlan and E. F. Bigelow, contains illustrated article on the Brownstone quarries.
2. Stone, Volume IX, No. I, June, 1894. Copiously illustrated article by Burton H. Allbee.
3. Mineral Industry, New York, Vol. III, 1894, pages 510-513.
4. Mineral Industry, Vol. IV, 1895, pages 555-558.

Papers on the fossils and the geological relations of the stone are to be found in the scientific journals and proceedings by the score. See Bulletin 85, U. S. Geological Survey, for list.

†Carboniferous Sandstones of Western Indiana, by T. C. Hopkins, in Twentieth Annual Report of the State Geologist of Indiana, 1895, gives an illustrated description of the brownstones of the State, with maps of the area.

‡This stone which could be quarried with profit in some localitias has here to compete with the famous Oolitic Limestone of Indiana on one side and the Joliet and Lemont stone on the other hand.

adapted to building purposes, being soft and easily worked, and at the same time exceedingly durable.

Maryland.

So far as known the only locality in Maryland where brownstone has been quarried for more than local usage, is near the mouth of Seneca creek, in Montgomery county. This stone is described by Merrill as of a light reddish brown color, even texture, and well adapted to all manner of building purposes and ornamental work, in fact he pronounced it one of the best of the Triassic brownstones. The Smithsonian Institute building erected in 1848 and 1854 from this stone shows, it is said, but few defects from weathering. In some portions of the rock there are numerous clay holes, but these may generally be avoided by careful selection. It could not be ascertained whether the quarries are now in operation or not, as two letters to the companies elicited no response.

Massachusetts.

The Triassic brownstone of the same age as the Portland stone, extends up the Connecticut valley as far as the northern boundary of Massachusetts, but so far as could be ascertained, the only place it has been quarried to any extent in the state is at East Longmeadow. The principal operators here are Norcross Bros., and James and Mara. Three other companies have been operating there in recent years, whether at the present time or not is not known. The quarries are located on the New England railroad between Springfield and Hartford, and within easy access of the Boston and Albany railroad.

The Norcross Bros. quarry three shades of stone, the trade names by which they are known being "Maynard," a bright red stone, "Kibbe," a dark red, and "Worcester," a brown. One or more of these shades no doubt occurs in the other quarries. No further information is at hand concerning the nature of the deposit or of the extent of the quarries. Analyses and tests of the stone are given in the tables on pages 13 and 30.*

Michigan.

Brown sandstone of the Potsdam formation occurs in considerable quantities along the shores of Lake Superior in Northern Michigan. It has been quarried at Marquette, Portage Entry and L'Anse. Letters of inquiry to the different companies said to be in operation there elicited responses from but two, the Portage Entry Quarries Co., who has quarries in the Portage Entry red stone and the Mar-

*References:
1. Stones for Building and Decoration, by G. P. Merrill.
2. Geology of Massachusetts, by C. H. Hitchcock.

quette brownstone, and the L'Anse Brownstone Company, with quarries at L'Anse, both companies having offices in Chicago.

At Portage Entry the stone is quarried quite extensively and shipped by boat to the different lake ports, and thence by rail to many of the cities throughout the United States. The stone is fairly well known in the eastern as well as the western markets.

The company reports about 10 feet of workable red stone overlain by 20 to 30 feet of rock. It is quarried by channeling machines, steam drills, and the use of the Knox blasting system. The quarries have been operated about 15 years. One variety of this stone as it appears in samples, has a brick red color, quite fine grain, and is rather soft, but not friable. So far as observed by the writer, it has no exact counterpart in the brownstones of this country outside of the Lake Superior region. It resembles closely some of the English stone that is imported into this country.

Another variety is that known as the "Raindrop Sandstone," which has a medium fine grain, light, brownish red color, mottled in places with gray. Analyses and tests of both varieties are given on page 13.

The L'Anse Brownstone Company operate quarries on the east shore of Keweenaw Bay, about two and one-half miles north of L'Anse, Baraga county, Michigan. The quarried stone is shipped both by rail and by boat. The stone in the sample furnished is a fine grained brownstone resembling the Connecticut stone, but having less mica, and (in the sample) free from pebbles.*

Minnesota

Red or brown stone has been quarried at New Ulm and various other points in the southwest part of Minnesota, and in larger quantities at Fond du Lac and vicinity, along the south shore of Lake Superior. The stone in the southwest part of the state is a quartzite similar to the well-known Sioux Falls stone, but said to be for the most part where it is worked in very thin layers. It appears to have little more than local usage.†

The stone at Fond du Lac is supposed to be of the same formation as that at New Ulm, and that further east at Marquette, in Michigan, that is, the Potsdam. It is said‡ to have in general a reddish brown color, variously marked with spots and stripes of lighter shade. It has occasional grains of quartz as large as a pea or even as large as

*References:
1. Stones for Building and Decoration, G. P. Merrill, New York, 1891, p. 264.
2. Report of the State Board of Geological Survey for the years 1891 and 1892, pp. 156 and 157.
3. A Sketch of the Geology of the Marquette and Keweenawan Districts, by M. E. Wadsworth, in Along the South Shore of Lake Superior, by Jul. Ralph.
4. The Sandstones of Lake Superior, by H. G. Rothwell, March Stone, 1894.

†The Stone Trade News, December 15, 1896, states that the red stone quarries at Jasper, Minnesota, employing about seventy-five men, shut down November 21 for the season.

‡Geology of Minnesota, Vol. I, p. 181.

a hen's egg, distributed through the lighter portion of it. However, a small portion is conglomeritic, and there is said to be a great abundance of stone of a good quality.

The stone consists about two-thirds of rounded and sub-angular grains of quartz and nine-tenths of the remainder feldspar, often crowded and darkened by ochre and ferrite, but sometimes white and occasionally a light green angular grain, apparently hornblende or augite. There are a few grains of black magnetite and a little calcite. (See tables for crushing tests and analyses.)

On the Great Northern and Eastern Minnesota Railway at Sandstone, on Kettle river, Pine county, is probably the largest and best equipped sandstone quarry in the state. It belongs to the Potsdam formation the same as the Fond du Lac, but is not properly classed as a brownstone, as it has a beautiful pink or salmon color. This is an exceedingly handsome stone, and the appearance of the stone in samples and the result of the test and analysis (see tables, pages 13 and 30), would indicate a stone of great durability. The quarries are operated by the Minnesota Sandstone Company, Minneapolis, and are said to be well equipped with modern machinery, and the stone mill fitted for work of all kinds.*

New Jersey.

The Brownstone quarries of New Jersey are the nearest competitors of those of Pennsylvania, and as such are of considerable interest.

The New Red formation continues in a northeast direction from the Delaware river, entirely through the state of New Jersey to the Hudson river in the state of New York. Brownstones suitable for building purposes have been quarried at a great many different places along the area. Some of these quarries have been in operation for many years, a number have been abandoned, some temporarily, some permanently.

The most productive quarries at present are those at Avondale, and those at Stockton (Prallsville). There are quarries at Newark, Little Falls, Raven Rock, Wilburtha and Princeton, operated to some extent. There are said to be active quarries at Martinsville and Warrenville.

Brownstone has been quarried at the following points, some of which may still produce good stone: Patterson, three quarries south of the city; Orange. Bells' quarry; New Brunswick, Jas. Neilson's quarry; Kingston; Milford, flagstone, Clark's and McGuire's &

*References:
1. Building Stones of Minnesota, by N. H. Winchell, in Geology of Minnesota, Vol. I, 1884.
2. Illustrated circular, Minnesota Sandstone Company.

Rawling's quarries; Woodville, Burrough's flagstone quarry; Alpine; Englewood, from drift boulders; Homestead, red sandstone, poor quality; Salterville, stone for local use only; Stone House Plains; Llewellyn Park; Snake Hill; Franklin Lake, local use; Haledon; Pompton, James Ludlam's quarry; Schuyler's Basin; West Orange; Washington Valley; Pluckamin, Dow's quarry; Barking Ridge; Ten Mile Run; Rocky Hill; Brookville, two quarries. Most of the quarries named are like many of those through the brownstone region of Pennsylvania, small openings operated at intervals to supply the local demand.

Probably the largest quantity of fine brownstone comes from the Avondale or Bellville quarries, operated by the Passaic Quarry Company and the Belleville Stone Company of New Jersey .

Quarries were opened here more than 100 years ago, and have been more or less extensively worked for 35 or 40 years. At one time (1881) there were 375 men at work producing annually stone valued at $225,000.

The brownstone is 50 to 70 feet thick, including considerable intercalary brown shale and some conglomerate. It has a gentle dip of 8-10 degrees to the west, so that the bed is getting deeper as it is worked from the outcrop. They are now below the level of the river and have much pumping to do. The color varies from a gray to a dark brown, but the prevailing color is a light brown. As with most brownstones it is of poor quality near the surface, being cut up by weathering agencies into small dimensions and is partially disintegrating. In the interior the beds are heavier and more regular, yet there is much waste throughout the whole bed. The most stone occurs near the bottom of the quarry. It has a moderately fine grain, works freely, and takes a smooth finish. It makes a desirable building stone, and has an extensive use in New York and other eastern cities.

The channeling machine is used a little in the heavier layers in the bottom of the quarry, but most of the stone is loosened from the quarry by wedging or blasting, the Knox blasting system being used.

The quarries are on the west bank of the Passaic river, and near the Newark and Patterson railroad, thus having shipping facilities both by water and by rail.

The quarries at Newark were at one time among the most productive in the State, the estimated value of the product in 1881 being $120,000. The condition at the present time is not known. They are about half a mile from the Passaic river and the Erie and the Delaware, Lackawanna and Western railroads. The quarry openings are 40 to 60 feet deep, in which the good stone is said to be 20 to 30 feet thick, associated with shale, and overlain wih glacial drift 10 to 20

feet thick. The even grain and the pleasing shade of color of this stone make it a much prized building stone.* The quarries in the city of Newark appear to have been abandoned.

The Stockton-Prallsville quarries are among the most extensive in the state. Only a small proportion of their product is used for buildings, almost the entire product being used for bridges. There are nine large openings, six of which are operated by the S. B. Twining Company, one by Wm. Ledger, one by John Ledger and one by the Pennsylvania Railroad Company. They are all close to the Belvidere division of the Pennsylvania railroad and to the feeder to the Delaware and Raritan canal. The stone, which is quite hard, varies in color from a light brown to a light gray, and very much resembles the Lumberville stone in its hardness and color, apparently from the strike of the rocks forming part of the same bed. There are several streaks of conglomerate, some of it quite coarse, with pebbles two or three inches in diameter. In one of the openings the stone is very coarse grained, containing large crystals of feldspar and quartz. Like the Lumberville stone, while it is quite hard to cut and dress, it is easily split, and can be readily made into rock faced work.

The Wilburtha (Greensburg) quarries were at one time among the most productive in the State, but at the present time they do not appear to be very active, some idle entirely, and some working on a very small scale. These quarries have produced great quantities of brownstone known in the markets as the Trenton Brownstone, the quarries being but a few miles above Trenton.†

The thickness of the stone in the Wilburtha quarries is 25 to 35 feet including some intercalary shale. Like all the stone of the Delaware valley it has a light brown color, not so light, however, as the Stockton and Lumberville stone, and about the same as the Yardley stone. It resembles the Yardley stone in its softness, being much softer than the Stockton stone. The Wilburtha quarries, like the Stockton quarries, are along the Belvidere division of the Pennsylvania railroad, and the Delaware and Raritan canal.

There are three quarries at Martinsville, New Jersey, but one of them has been abandoned, and the other only furnishes rough stone for foundations. The Bartte quarry furnishes large quantities of fine cut stone for buildings, most of it a light gray color.‡

Handsome building stone has been quarried at Little Falls, Trinity Church and Trinity Chapel, New York, and the United States Custom House and Postoffice, at Newark, attesting its beauty. There

*The data in regard to the Newark quarries is from the Annual Report State Geologist of New Jersey, for 1868 and 1881.

†Trenton brownstone now may mean stone from any of the Delaware valley quarries; besides the Wilburtha quarries, it includes the Yardley, Pennsylvania; Stockton, New Jersey, and Lumberville, Pennsylvania, quarries.

‡Annual Report State Geologist, New Jersey, 1881, p. 54.

are said to be three grades, a light brown, a light gray, and a dark brown.

Three quarries have been operated at Patterson, but are not known to be active at present. At Pleasant Valley and Washington Valley are quarries where nice brownstone has been quarried in years past.

New York.

Limiting the term brownstone to the brownstone of Triassic age, New York has little worth mentioning, there being only a few small quarries which furnish stone for local use, located along the Hudson, at Nyack and Haverstraw.

Valuable quarries of red and brownstone occur in New York in formations other than the Triassic. From the Potsdam sandstone of Lower Silurian age near Potsdam, pink and red sandstone are quarried in large quantities. The stone is hard, strong, durable, fine grained and a valuable building stone. It might almost be called a quartzite, so hard it is. Despite the fact that it is difficult to quarry and work, it is an important and valuable stone, because of its beautiful color and great strength and durability.

It is quarried extensively by the Potsdam Red Sandstone Company and the Clarkson Quarries Company. In a series of comparative tests published by Professor Smock,* the Potsdam stone stood the tests better than any other stone on the list.

The Potsdam stone is quarried at Port Henry and other points in New York, but as it is mostly of a gray color† it does not come in the province of this report.

The most important brown or red stone in the State is that from the Medina red formation in the western part of the State. The principal quarries are located along the New York Central railroad west of Rochester, at Medina, Albion, Lockport, Hindsburg, Hulberton, Holley and Brockport. Merrill says‡ the leading varieties are three, known as the Medina red stone, the white and gray Medina, and the variegated red and gray. The quarries in this district are worked on an extensive scale, and their equipment is adequate to a large annual production.

The aggregate output is larger and more valuable in dimension stone for dressing than any other quarry district in the state. The stone has gained a well deserved reputation for its value as a beautiful and durable building material, and its more general employment, both in construction and in paving is much to be desired.

This stone has been used extensively in Buffalo, both in paving and in construction, a great many churches and fine residences being

*Bulletin New York State Museum, Volume II., No. 10.
†Bulletin New York State Museum, Volume III, No. 15, pp. 391-4.
‡Bulletin No. 16, Volume III, New York State Museum, pp. 386.

built of it. It is fully as brown as much of the Triassic brownstone, but hardly as uniform in color.

The Medina stone has also been quarried at Oswego, Oswego Falls and Granby, Oswego county, that at the first two localities being of an inferior quality. The quarry at Granby on the Delaware, Lackawanna and Western railroad operated by the Granby Brownstone Company, produces a fine grained purplish red stone used for building in the neighboring towns.*

North Carolina.

The Triassic brownstone of the same age and similar in appearance to that in the more northern states occurs in commercial quantities in several places in North Carolina. It has been quarried at Wadesborough, Anson county; Gulf and Egypt, Chatham county, and Sanford, Moore county. Letters of inquiry to the different companies said to be in operation recently elicited replies from but one, the Aldrich Stone Company at Sanford, who opened a quarry in 1893, which has been in active operation since that time. This quarry is located on the Seaboard Air Line and Cape Fear and Yadkin Valley railroads, and they ship stone over both roads to the southern and eastern cities.

The company reports a thickness of 12 feet of stone that have been worked, with a second layer not yet opened. A sample of the stone furnished by the company shows a strong stone of light, pleasing color, intermediate in shade between the bright red of the English stone, and the dark brown of the New England stone. See tables pages 13 and 30 for tests.

At Wadesborough it is said† the stone lies in beds from two to ten feet in thickness, which are inclined to an angle of 25 degrees. It has a fine, even grain, dark brown and reddish colors.

Ohio.

Brownstone occurs in several places in Ohio, as shown by the samples in Orton Hall, at the Ohio State University, at Columbus, but the only one known in the general market is the Killbuck stone. The quarry is located on a hill about three quarters of a mile above the Killbuck station, on a branch of the Akron, Cleveland and Ohio

*References:

1. Building Stone in New York, by J. C. Smock. Bulletin New York State Museum, Volume II, No. 10.
2. Building Stones in the State of New York, by J. C. Smock. Bulletin New York State Museum, No. 3, March, 1888.
3. Report on Building Stones by James Hall, in Thirty-ninth Annual Report New York State Museum, 1886.
4. Mineral Resources of New York State, by F. J. H. Merrill. Bulletin New York State Museum, Volume III, No. 15, 1895.
5. Stones for Building and Decoration, by G. P. Merrill, New York, 1891.
6. Potsdam Red Sandstone, illustrated; Stone, Volume VI, No. 4, pp. 289-301, March 1893.

†Merrill—Stones for Building and Decoration, p. 274.

railway, which distance the stone is hauled by wagon. The quarry has been operated since 1886 by the Killbuck Sandstone Company, and the stone has been shipped to many towns in Ohio, to Pittsburg, Pennsylvania, and in small quantities to other states.

The stone is quite variegated in color, in fact as far as could be observed, there is no stone of uniform color in the quarry, nor in the buildings in which it has been used. The color varies from dark gray to dark brown. It is coarse grained, even fine conglomerate in places. The thickness of the quarry stone varies from eight to thirty feet in different parts of the quarry; the overlying material consisting of shale and sandstone is 25 to 30 feet thick in the middle of the quarry.

The stone is apparently a strong, durable one, but can never be classed with the finer building stones, because of its variegated color. The drilling is done by hand and the stone wedged or blasted loose.

Another quarry is being opened (1896) about a mile north of the Killbuck station, which is said to have a thickness of 45 feet of stone of more uniform color than the older quarry.

South Dakota.

At Sioux Falls, South Dakota, there is a red quartzite that has been used to some extent for building stone. While some of it has been used in Chicago, and a little in the eastern cities, the output is not large, and within the last year or two the quarries have either been idle or running on a small scale. Letters to the different companies elicited no response.

It resembles the Potsdam stone of Potsdam, New York, in some respects, but seems to be even more quartzitic. It resists a pressure of 25,000 pounds to the square inch, and will take a brilliant polish. Like the Potsdam stone it varies from pink to red. It is adapted to either exterior work or interior decoration, where the expense of working it will justify its use. While one of the most durable and handsome stones, it is very difficult to work. It is well adapted to city work, as it is not easily abraded nor easily discolored. Professor Beyer, of Ames, Iowa, who has written a thesis on this stone,* says it has been quarried at Sioux Falls, Dell Rapids and Garretson, South Dakota, Granite in Iowa, and Pipestone and Lucerne in Minnesota, but in all these places, he says, little has been done in the last three or four years.

Virginia.

The Triassic brownstone occurs in several small areas in the state of Virginia, but as far as could be ascertained the only place it has been quarried to any extent is in the vicinity of Manassas, and so far

*The Sioux Quartzite and certain associated rocks, by Samuel W. Beyer, in Iowa Geological Survey, Volume VI, 1896.

as is known, there is only one quarry in operation there. That belongs to J. R. Tillett, who has owned the quarry about seven years, but it has been in operation about thirty years. It is located on the Richmond and Danville railroad, owning its own side track. The stone is described by Merrill as occurring in horizontal layers* near the top of a low hill. The layers vary in thickness from one to six feet, and have been quarried to a depth of about 20 feet.

Wisconsin.

Brownstone occurs in Wisconsin on the south shore of Lake Superior, not far west of the Michigan border. The stone is said to resemble the Portage Entry stone, and belongs to the same age. There are quarries on Bass Island and on Wilson Island, and at Houghton and Washburn, the two latter having boat and railway transportation, while the others ship by boat.

The Prentice Brownstone Company has extensive quarries at Houghton, Michigan. Analysis and tests of their stone are shown in the tables on pages 13 and 30. No samples or description of the stone is at hand, nor could replies be secured from any of the other companies.

Professor Conover states† regarding Lake Superior stone in Wisconsin, that it is composed of siliceous grains, medium to coarse, in an iron or clay cement, and varying from yellow to deep brown in color. It furnishes a handsome building stone, the chief difficulty being the numerous clay pockets that pit the surface of the stone. There are numerous exposures on the islands and along the lake shore where the stone can be loaded directly from the quarry on the boat. The large quarry at Bass Island, not then (1880) in operation, has a thickness of 26 feet of good brownstone of much the same grade as the Marquette stone, overlain by a heavy clay stripping.

English and Scotch Red Stone.

‡Red sandstones are quarried extensively in both England and Scotland, but a comparatively small quantity is imported into this country.|| The best stone that is imported into this country is said to come from the Annan District, Dumfries, Scotland, and Cumberland county, England. The Gatelawbridge Scotch redstone is also used in New York. The Murray quarry of Annan is said to be the largest of all and furnishes more redstone to this country than any other quarry.

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*Stones for Building and Decoration, p. 284.

†Tenth Census, Volume X, p. 230.

‡The writer is indebted to George W. White, of New York, and Frank Williamson and William Gray & Sons, of Philadelphia, for information concerning the foreign stones in this country.

||A description of the principal varieties may be found in Hull's Building and Ornamental Stones, and a briefer description in Merrill's Stones for Buildings and Decorations.

The bright red color, and the ease with which it is worked, are points in favor of most of the foreign stone, as none of the eastern stones of this country have as bright a color as the foreign stone, but one variety of the Michigan stone, from Portage Entry, that is now coming into the eastern markets very closely resembles the foreign stone in color, and the red stone from East Longmeadow is said to resemble it somewhat. The red stone from these two localities is said to be largely replacing the English and Scotch redstone in the eastern markets.

Some of the buildings in Philadelphia in which the foreign red stone is used are the Bourse, Fidelity and Trust Building, Bank of the Republic, Wood, Brown & Company building, and John C. Bullitt's residence. The stone is said to withstand the climate better in this country than in England.

The tenth census report gives red and brown sandstone used in New York city from the following localities: Corsehill (near Annan) about 60 miles west of Glasgow, dark red to bright pink, close grained, weathers well, works easily; Ballochmile, Forfarshire, Scotland, darker than the Corsehill stone; Gatelawbridge, 30 miles from Ballochmile; and Frankfort-on-the-Main, Germany.

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General View of Station Buildings.

ANNUAL REPORT

OF

The Pennsylvania State College

FOR THE YEAR 1896.

Part II.

AGRICULTURAL EXPERIMENT STATION.

(Part I contains the Reports of the Departments of Instruction.)

CLARENCE M. BUSCH,
STATE PRINTER OF PENNSYLVANIA.
1897.

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*To September.
†From September.

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FINANCIAL STATEMENT.

A.—*The United States Appropriation for the United States Fiscal Year ending June 30, 1896.*

The Pennsylvania State College Agricultural Experiment Station, in account with the United States Appropriation, 1896:

Dr.

To receipts from Treasurer of United States, as per appropriation for year ending June 30, 1896, under the act of Congress approved March 2d, 1887,		$15,000 00

Cr.

June 30.	By Salaries,	$11,634 97	
	Labor,	348 95	
	Publications,	815 32	
	Postage and stationery,	422 75	
	Heat, light and water,	477 31	
	Chemical supplies,	187 99	
	Seeds, plants, etc.,	30 18	
	Fertilizers,	93 54	
	Feeding stuffs,	449 34	
	Library,	15 50	
	Tools, implements and machinery,	58 55	
	Furniture and fixtures,	1 25	
	Scientific apparatus,	53 69	
	Live stock,	90 96	
	Traveling,	255 29	
	Contingent expenses,	38 00	
	Buildings and repairs,	26 41	
		$15,000 00	$15,000 00

State College, Pa., November 23, 1896.

We, the undersigned, duly appointed auditors of the Experiment Station Accounts, do hereby certify that we have examined the books and accounts of the Agricultural Experiment Station of the Pennsylvania State College, for the fiscal year ending June 30, 1896; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance to be accounted for in the fiscal year commencing July 1st, 1896.

(Seal.)

Attest:

H. A. McELWAIN,
Custodian.

GABRIEL HIESTER,
H. V. WHITE,
Auditors.

B.—*Total Receipts and Expenditures, all sources, for the year ending June 30, 1896.*

RECEIPTS.

	U. S. Appropriation Account.	General Account.	Total.
United States appropriation account,	$15,000 00		$15,000 00
Horticultural department,		$50 19	50 19
Fertilizer analysis,		7,606 02	7,606 02
Library,		11 19	
Live stock,		113 03	22 07
Pennsylvania State College,		38 79	38 79
Food analysis,		79 50	79 50
Farm,		1,346 42	1,346 42
Excess of expenditures over receipts,		484 93	484 93
	$15,000 00	$9,730 07	$24,627 92

EXPENDITURES.

Light, heat, etc.,	$477 31	$73 76	$551 07
Farmer's institutes,		4 73	4 73
Contingent expense,	38 00	197 08	235 08
Building and repairs,	18 07	590 62	608 69
Interest,		416 07	416 07
Dairy,	6 89	178 26	185 15
Postage,	422 75	185 26	608 01
Labor,	357 29	4,347 89	4,705 18
Tobacco experiments,		373 18	373 18
Feeding stuffs,	449 34	16 11	465 45
Salaries,	11,634 97	1,256 14	12,891 11
Seeds, plants, etc.,	23 29	16 59	39 88
Chemical supplies,	187 99	995 99	1,183 98
Publications,	815 32	414 75	1,230 07
Furniture and fixtures,	1 25	6 60	7 85
Fertilizers,	93 54	10 76	104 30
Library,	15 50		4 31
Traveling,	255 29	279 21	534 50
Tools, implements, etc.,	58 55	266 72	325 27
Live stock,	90 96		
Scientific apparatus,	53 69		53 69
Meteorological observations,		52 00	52 00
Expenses of advisory committee,		10 28	10 28
Telephone rent,		27 45	27 45
Exhibits,		10 62	10 62
	$15,000 00	$9,730 07	$24,627 92

REPORT OF THE DIRECTOR.

The work of the Experiment Station during 1896 has been continued along substantially the same lines as in previous years and but few changes have been made in the personnel.

Mr. M. S. McDowell, Assistant Chemist, tendered his resignation on September 7th, to accept a more lucrative position elsewhere. Mr. C. A. Browne, Jr., was appointed to the vacancy thus occasioned and later Mr. C. W. Norris was employed temporarily as assistant chemist, additional assistance in this department being required to perform promptly the work of fertilizer and food analysis.

An enumeration of the various experiments which have been in progress during the year would be so largely a repetition of previous reports that, in place of this, I desire to present some considerations regarding the main features of the work of the Station and their possible development, referring to the detailed papers appended as part of this report for specific information regarding the work accomplished.

Tobacco Experiments. As stated in my last annual report, a special appropriation for these experiments was voted by the Legislature of 1895 but was vetoed by the Governor. In order to prevent a lapse of the experiments and the consequent practical loss of much of the work already done, the State Department of Agriculture undertook to defray the expenses of the work from its fund for special investigations. Under this arrangement, work has been carried on in Lancaster and Bradford counties. One set of plots in Lancaster county, namely that at Rocky Spring Park, had to be abandoned owing to a change in the management and the unwillingness of the lessee to continue the arrangement. It was not deemed wise under the circumstances to attempt to secure another location and work in that county has consequently been confined to the location at Donegal on the farm of Hon. J. D. Cameron, to whom as well as to his manager, Mr. J. C. Rutherford, we are under obligations for opportunity to continue these experiments for several years in the same locality. In Bradford county it also became necessary to relocate the experiments, which are now being carried on upon the farm of the Hon. Louis Piollet at Wysox.

The work has been upon the same general lines as heretofore. The experiments with fertilizers have been directed primarily to the pro-

duction of a leaf of high quality for wrapper purposes, the question of quantity being secondary. The curing experiments with artificial heat have been continued at Donegal with most satisfactory and promising results. At the same time both the question of the use of fertilizers and of curing need further and continuous investigation. Since the inauguration of the experiments we have had but one good tobacco season, namely, that of 1896, and the season, as is well known, is a very important factor in determining the quality of the tobacco crop. Moreover, the tests with fertilizers should be continued for a series of years in order to demonstrate the effects of their continuous use. The matter of curing by artificial heat, which enables the grower to control the conditions, is still in its infancy, and while very promising, has hardly yet reached the stage of being an assured commercial success. Some tests of varieties of tobacco have been made which promise interesting results, and it would be very desirable also to make experiments upon the lighter soils of Northern Lancaster county and likewise to investigate the question of irrigation as applied to tobacco.

Work of this character, to be of permanent value and worth the money expended upon it, should be done in a scientific manner and carefully checked at all points by laboratory tests. At the same time, however, it needs for its successful prosecution the widest practical experience in the growing and handling of the crop. The experiments were therefore wisely made co-operative, enlisting the scientific resources of the Experiment Station on the one hand and the practical experience of the organization of tobacco growers on the other, and it is to be hoped that the present Legislature will take such action as may seem wise looking toward a continuance of these valuable and interesting experiments.

Soils and Fertilizers. The analysis of commercial fertilizers in connection with the control of the fertilizer trade exercised by the Department of Agriculture has now been performed by the Station for eight years. This combined work of the Department and the Station is of the utmost value in informing farmers as to the quality and value of fertilizers sold in the State and in preventing fraudulent practices. Notwithstanding all this, however, there is no question that much money is entirely wasted in the purchase of commercial fertilizers. The Secretary of Agriculture estimates that the farmers of Pennsylvania spend about $4,000,000 yearly for fertilizers of which fully one-fourth is virtually thrown away. Undoubtedly a portion of this enormous waste arises from general ignorance as to the use of fertilizers, but very much of it is also due to lack of acquaintance with the specific needs of soils and crops. A good illustration of the importance of this matter is given by the soil test with fertilizers reported in Bulletin 35 of the Station and reprinted in this report,

in which it is shown that the intelligent as compared with the unintelligent use of fertilizers increased the profits of the potato crop nearly $50 per acre.

This knowledge was brought out in this particular instance by means of a comparatively simple soil test made by the farmer himself. But while, in exceptional instances, farmers may experiment, it may be accepted as a fact that such work will not usually be done successfully. To most busy farmers, the conduct of a field test with fertilizers appears like an impossible task and particularly is this true of farmers upon the poorer and rougher lands of the State where knowledge of this sort is particularly needed. There is a call for a broad general study of the soils of the State; their chemical, physical and agricultural properties and their specific needs for fertilizers. Such a study would do much to prevent the great economic loss mentioned above, and would furnish information of the utmost value to the intelligent farmer. Such investigations would seem particularly in place in those sections of the State which are practically just beginning to be occupied for agricultural purposes. A soil survey of this sort might save the farmers of these sections long and costly efforts to grow crops not adapted to their soil and locality or, on the other hand, might help them to fertilize and handle soil and crop to best advantage. The Experiment Station has done work of this sort on its own grounds, but has not been in position to go further. I earnestly hope that it may soon be possible to largely extend this branch of our work.

Horticulture. Hitherto, the horticultural work of the Station has been confined largely to variety tests of vegetables and fruits. With the opening of the last season, however, this policy was changed. The testing of garden vegetables was dropped entirely and that of fruits confined to varieties not on the market, together with a few standard varieties grown for comparison. In lieu of the work thus dropped, an investigation of fruit growing in the State has been begun. For obvious reasons, the peach was selected as the first object of study. The Horticulturist of the Station has visited growers, nurserymen, and marketmen in various sections of the State, and I beg to refer to his report, printed as Bulletin 37 of the Station and reproduced in this report, for details. This is a very important line of work. As a result of the present agricultural depression farmers are universally seeking new crops which may be better adapted to present conditions than the staples and which may bring them larger returns. Large sections of this State can grow fruit and the general interest in this subject is increasing. The Station can render important aid to those contemplating embarking in this industry by bringing to them information like that contained in Bulletin 37. Moreover, the numerous problems which beset the practical fruit

grower are such as call for the best aid which science can offer for their solution. A study of present conditions, like the one already undertaken, should be followed by experimental work both local and general. Furthermore, the market-gardening and floricultural interests near the large cities are of great importance and as yet we have not been able to do any considerable amount of work in their interest. In order to properly occupy this extensive field, the Station should have largely increased funds to devote to this subject. The neighboring State of New York is now appropriating annually $24,000 for special investigations in horticulture and under the efficient management of her two experiment stations is powerfully aiding in building up the horticultural interests of the State. While these interests in Pennsylvania are relatively less important than in New York, yet for this very reason they call all the more loudly for aid in developing this very promising branch of agriculture.

Dairy Feeding and Dairying. These two correlated subjects have constituted the main line of Station activity, their present importance and prospective greater importance fully justifying this choice. World-wide competition in the production of staples, especially bread-stuffs, is forcing the farmer into other lines. For those who are fitted for it, both in themselves and their surroundings, the production of fine dairy goods is one of the most important directions in which relief may be sought.

For the successful prosecution of the dairy industry, however, perhaps even more than for other branches of farming, special knowledge and skill are requisite to attain the highest success. For this the dairymen of the State naturally look to the Agriculture College and Experiment Station. Accordingly a large share of the attention of the Station has been given to the subject of the building up of a dairy herd, the profitable feeding of dairy cows and to the manufacture of butter and cheese. As regards the technology of dairying the activity of the institution has been largely in educational lines, dairy courses having been successfully carried on for the past five years. In addition to the work of instruction, however, the Experiment Station has made somewhat extensive tests of dairy machinery, has made some experiments in the manufacture of domestic cheese, and has made arrangements for supplying correctly graduated testing apparatus to creamerymen.

In the management of its own dairy herd, the Station has aimed to exemplify those principles which should control the dairyman in the pursuit of the same object. Beginning in 1889 with comparatively poor stock, the Station has, without any extravagant expenditures for fancy stock, graded up its herd until its production now averages about 350 pounds of butter per year. A bulletin giving the details of the process and the averages of the herd for successive years is now in preparation.

The experiments on dairy feeding have included a study of forage crops, their cultivation, yield, and the methods of preserving them; the soiling question; and the economic feeding of dairy cows as to amount and quality of ration.

The work of the Station on forage crops and upon the soiling system was quite fully summarized in my annual report for 1894. For the past three years, our main line of experiment in this direction has been a study of the relations which exist between the amount and composition of the food and the yield of milk and butter, particularly with reference to financial considerations. Notwithstanding the large number of feeding experiments with dairy cows which are on record, but little attention has been given directly to this point. The majority of feeding experiments are comparisons of different feeds rather than a direct study of the relations of feed to product. They have given results of the greatest value but not results which are immediately applicable to this question. Plainly, however, until we know fully what disposition the animal makes of the several constituents of its food and how this disposition is affected by the amount and composition of the food, by the individuality of the animal and by the external conditions, we are not in position to use feeding stuffs intelligently. The subject is a broad one and while some of its aspects seem remote from practical utility, yet ultimately they are matters of great practical importance to the dairyman, and it is proposed to continue work along these general lines. In other words, it is proposed that the Station shall endeavor to become, so far as possible, by exhaustive study and experiment, an authority upon dairying and dairy feeding in all their aspects for the benefit of the dairymen of Pennsylvania.

Grouping of Work. With the above suggestions carried out, the work of the Station would group itself about three main lines.

1. Soils and fertilizers, including the fertilizer analysis, the special tobacco experiments and the proposed soil survey.

2. Horticulture, including such variety work as seems desirable, but paying special attention to the subject of fruit-growing in the State.

3. Dairy husbandry, including dairy feeding and the manufacture of dairy products.

These three main lines of work are far from covering all the aspects of agriculture in the Commonwealth and it would be very easy to suggest important additional lines of work. An Experiment Station, however, is usually in danger of undertaking too many rather than too few things and it should be our policy to concentrate our efforts rather than to dissipate our energies upon many subjects. For the present, it will be the aim of the Station to strengthen these main lines of work, adding new subjects only as adequate funds can be secured.

State Aid. Some of the suggestions made above look in the direction of State aid to the Experiment Station. It may be proper therefore to append a statement of what the State has already done in this direction. The appropriations of the State to the Experiment Station have been as follows:

Legislature of 1887,	$12,000
Legislature of 1889,	7,000
Legislature of 1893,	4,000
Total,	$23,000

Of these, the appropriation of 1887, which was for four years, was employed in the erection of the present Station building. The appropriation of 1889 was a special appropriation for the enlargement of the farm buildings, and that of 1893 was the appropriation for cooperative tobacco experiments not located at the College. There has been no direct appropriation by the State for the current work of the Station. Its income is derived entirely from the United States fund (Hatch fund), what it earns in fees for the analysis of fertilizers and foods and the sales from the Station farm.

It can hardly be assumed that Congress in providing national support for the Experiment Stations intended to relieve the several States of all responsibility for the development of their own agriculture and the study of their own special problems. As a matter of fact, many of the States are adding largely from their own funds to the United States appropriation. In 1894 there were thirteen States whose Station or Stations received a total income of over $20,000. In these States, the percentage of the total income derived from the United States fund, from State funds, from fees and other sources was as follows:

	Total Income.	Percentages Derived from			
		United States.	State.	Fees.	Sundries.
California,	$23,000 00	65.22	34.78	.....	.....
Connecticut (two stations),	29,053 68	51.62	27.54	19.40	1.44
Louisiana,	38,150 00	39.32	38.01	9.83	13.24
Massachusetts (two stations),	29,623 37	50.64	33.76	10.13	5.47
Minnesota,	27,583 27	54 38	45.62	.....	.....
Montana,	23,000 00	65.22	.....	.....	*34.78
New Jersey (two stations),	26,000 00	57.70	42.30	.....	.....
New York (two stations),	74,792 76	20.05	78.88	.....	1.07
North Carolina,	23,665 82	63.38	33.80	.....	2.82
Ohio,	43,480 41	34.50	41.63	.....	23.87
Pennsylvania,	28,925 25	51.86	5 19	37.16	5.79
West Virginia,	24,445 50	61.36	.....	.....	38.64
Wisconsin,	25,450 00	58.94	21.42	.....	19.64

*Individuals and communities.

Excluding the figures for West Virginia for special reasons, the other eleven States show the following average as compared with Pennsylvania:

	Total Income.	Percentages Derived from			
		United States Appropriation.	State.	Fees.	Sundries.
Average of eleven states.	$33,072 66	45.36 per cent.	42.50 per cent.	3.40 per cent.	8.74 per cent.
Pennsylvania, ...	28,925 25	51.86 per cent.	.9 per cent.	37.16 per cent.	5.79 per cent.

It thus appears that in these eleven States the average total income was about $4,000 greater in Pennsylvania; that of this greater income 42½ per cent. was derived from the State as compared with a little over 5 per cent. in Pennsylvania, while, on the other hand, in these eleven States, 3.4 per cent. of the average income was derived from fees, while the Pennsylvania Station earned over 37 per cent. of its income in this way. Making the same comparison with the three neighboring States of New Jersey, New York and Ohio, we have the following figures:

	Total Income.	Percentages Derived from			
		United States Appropriation.	State.	Fees.	Sundries.
Average of New Jersey, New York and Ohio, .	$48,091 06	31.19 per cent.	61.07 per cent.	. . . . .	7.74 per cent.
Pennsylvania, ...	28,925 25	51.86 per cent.	5.19 per cent.	37.16 per cent.	5.79 per cent.

In these three States, the average amount expended upon Agricultural Experiment Stations was about $9,000 greater than in Pennsylvania. Of this larger amount, the State furnished 61 per cent., as against 5 per cent. in Pennsylvania, while the Pennsylvania Station earned 37 per cent. of its income in the form of fees as against nothing in the other three States. As compared, then, with the neighboring States or with the larger Stations throughout the country, it is evident that the income of our own Station is considerably smaller in amount, that a disproportionate amount of it is derived from fees, and that the State's contribution is relatively very small. In view of these facts, the suggestion above made, of special appropriations for a study of the soils of the State and of the fruit-growing industry, does not seem out of place.

Publications. For the purpose of bringing the results of its investigations before the public, the Station publishes an annual report and at least four bulletins annually. These publications are mailed regularly to every newspaper published in the State, as well as to all important agricultural papers in other States and to all residents of the State who apply for them, so far as the supply will permit. The bulletins published during 1896 were as follows:

No. 34. January. A Phosphate Deposit in Juniata County.
No. 35. April. A Soil Test with Fertilizers.
No. 36. May. Chestnut Culture for Fruit.
No. 37. November. The Peach Industry in Pennsylvania.

Short newspaper bulletins of a popular character are also issued from time to time and mailed to all newspapers in the State which express a desire to receive them. The mailing list of the Station has been rapidly increasing of late, large numbers of applications for Station publications having been received as the result of the representation of the Station at the farmers' institutes. The Station mailing list now includes about 17,360 addresses within the State besides a considerable number outside the State. Our supply of the annual report has become entirely inadequate to meet this demand. At present, the State prints 16,560 copies of the report, of which the Station receives 8,000 for distribution, the remainder being distributed largely through members of the Legislature. In the past, the Station has succeeded in supplying nearly its whole list by securing the quotas of city members of the Legislature, but the rapid increase in the mailing list of late renders this no longer feasible. Unless an immediate increase in the number of reports printed can be secured, it will become absolutely necessary to revise and reduce the mailing list of the Station, which would be exceedingly unfortunate, since the work of the Station becomes of practical value only as it becomes known to the farmers of the State.

The expense of printing the bulletins of the Station has hitherto been borne by the Station and with the large edition necessary to supply our mailing list has become a heavy tax upon its funds. In the majority of other States, the bulletins as well as the reports of the Experiment Station are public documents and it is hoped that this arrangement may ere long be made in our own Commonwealth.

In addition to the regular bulletins reporting the investigations of the Station, we have recently begun also the publication of a series of bulletins of information. The first of these was prepared late in the year and distributed at the farmer institutes and to the mailing list of the Station.

This bulletin was entitled "The Computation of Rations for Farm Animals," and is reprinted, with the addition of colored charts, in this report. It is to be hoped that it will prove feasible to follow it with others upon various aspects of agriculture. It is my belief that this general line of work is a very important one. The special demand of the farmer at present is for information regarding what is known of the principles of agriculture rather than for special investigations in particular directions. It is hoped that the publications of these bulletins of information may be continued as an important adjunct to the work of the Chautauqua Course of Home Study and that provision may also be made for College Extension lectures in Agricul-

ture. In all these ways it is our purpose, so far as our means permit, to bring the results of our own experiments and of the investigations and experience of students of agriculture everywhere to the aid of the Pennsylvania farmer in his struggle with the changing economic and social conditions which now confront him.

2—22—96

THE COMPUTATION OF RATIONS FOR FARM ANIMALS.

BY HENRY PRENTISS ARMSBY.

INTRODUCTION.

The investigations made by the Agricultural Experiment Stations of this and other countries during the last forty-five years have resulted in the accumulation of a large amount of valuable information regarding the scientific principles of stock feeding. Thanks to these investigations, it is now possible for the feeder, by consulting tables showing the composition and digestibility of feeding stuffs and by making comparatively simple calculations, to adapt his rations with a considerable degree of accuracy to the purpose he has in view.

Such tables have been frequently published, but experience shows that, in most cases, even the more intelligent farmers do not find it easy to put them to practical use. The truth of this statement is shown not only by the correspondence which comes to the Station, but very strikingly by the numerous letters received by agricultural papers asking to have rations computed. Answers to inquiries of this sort have come to be a prominent feature in many such papers and are doubtless helpful to the inquirers. At the same time it is plain that on many accounts it would be far better for the farmer to make these computations for himself if possible, since he best knows the conditions which surround him and is thus best fitted to adapt his rations to his conditions.

It is hoped that this publication will prove helpful to those who desire to compute rations for themselves. It does not purport to contain any information that has not been frequently published before but consists simply of a brief outline of the general principles on which the computation of rations depends, followed by somewhat detailed illustrations of the method of solving some of the more important problems that arise in practice.

PART I.

GENERAL PRINCIPLES.

Composition of Animals. The very large number of different substances found in the animal body may for our present purpose be grouped under four heads.

1. *Water.* This is one of the principal ingredients of the animal body, amounting to from forty to sixty per cent. of the weight of the live animal.

2. *Ash, or Mineral Matters.* These amount to from two to five per cent. of the weight of the live animal. Their presence is most evident in the bones, but they exist also in small proportion in all parts of the body and are just as essential as any of the other ingredients.

3. *Protein.* A name given to an important group of substances of which washed lean meat or the white of egg may be taken as the type. They all contain about sixteen per cent. of the element nitrogen, which is entirely lacking in the three other groups, and are remarkably similar in their general properties. The organic part of the bones, the ligaments and muscles which bind together and move the bones, the skin, the internal organs, the brain and nerves, in short, all the working machinery of the body, are composed very largely of protein. Consequently, this group of substances is of great importance, and a due supply of it in the food, particularly to growing animals, is indispensable.

4. *Fat.* This term needs no special explanation. The proportion of fat in the body varies greatly, but seldom falls below six or rises above thirty per cent.

The average composition of different animals in various stages of fattening is given in Table I of the Appendix.

Composition of Feeding-Stuffs. In the various feeding stuffs which serve to build up and maintain the animal body, we find the same four groups of ingredients which we do in the body of the animal, namely: water, ash, protein and fat. The individual substances which make up these groups differ more or less from those found in the body of the animal, but for our present purpose these differences may be regarded as of comparatively little importance.

In addition to these four groups, feeding stuffs contain another group of substances, not found to any considerable extent in the body of the animal. This group is known as carbhydrates. The most familiar substances belonging to this group are starch, the various kinds of sugar, and woody fiber. Starch being the most abundant of these in most foods, this class of substances is some-

times spoken of as starchy substances, but the technical name "carbhydrates," is on the whole more accurate and expressive.

The following tabular statement may help to fix in the mind the statements which have just been made regarding the composition of animals and feeding stuffs.

Ingredients of Animals.	*Ingredients of Feeding Stuffs.*
1. Water.	1. Water.
2. Ash.	2. Ash.
3. Protein.	3. Protein.
4. Fat.	4. Fat.
	5. Carbhydrates.

Table II of the appendix shows the average composition of a considerable number of American feeding stuffs. In this table the common practice has been followed of dividing the group of carbhydrates into two portions. The "crude fiber" or "woody fiber" is stated separately, partly because it is thought to be of somewhat inferior nutritive value and partly because it gives some indication of the bulkiness and woodiness of the feeding stuff. The column headed "nitrogen free extract" includes all the carbhydrates except the crude fiber.

Digestible Matters in Feeding-Stuffs. It is plain that the value of any feeding stuff will not depend simply upon the total amounts of these various ingredients which it contains, but also upon the proportion of them which the animal is able to digest and assimilate. In Table III of the appendix are given the percentages of digestible matter contained in the same list of feeding stuffs which is given in Table II. The figures of Table III, consequently, indicate with a considerable degree of accuracy the relative values of the different feeding stuffs, since they show to the best of our present knowledge the amount of real food which each one contains.

Table III also shows, in the first column, the percentage of total dry matter in each feeding stuff. By dry matter is meant all of the feeding stuff except water. Thus, the first feeding stuff given in the table is stated to contain 20.3 per cent. of dry matter. This means that in every 100 pounds of this feeding stuff there are 100—20.3= 79.7 pounds of water and 20.3 pounds of solid matter. In other words, the percentage of water given in Table II and the percentage of dry matter given in Table III, when added together, equal 100.

The digestible carbhydrates and fats have been added together in Table III because they serve substantially the same purposes in nutrition, as explained in the next paragraph, and it therefore simplifies calculation to unite them.

Uses of Ingredients of Feeding-Stuffs.—Having learned the amounts and proportions of digestible matters present in different

COMPOSITION OF FEEDING STUFFS.

Digestible Protein | Digestible Carbhydrates | Digestible Fat (x 2¼)

Total Ash. | Indigestible. | Water.

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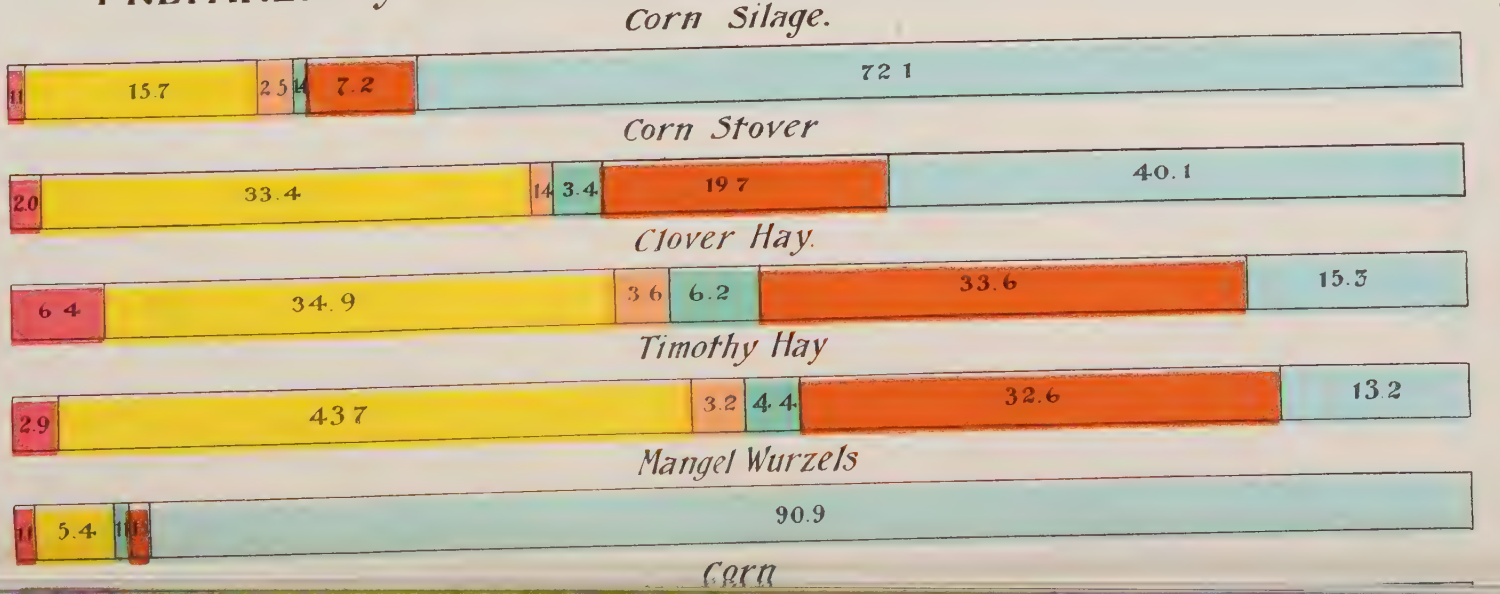


Oats
9.2
47.3
5.9
3.0
23.6
11.0
Peas
18.8
51.2
2.3
2.7
10.6
14.4
Wheat Bran
12.0
38.9
6.5
5.8
24.9
11.9
New Process Linseed Meal
28.9
38.8
6.1
5.8
10.3
10.1
Cotton-Seed Meal
37.2
15.1
28.6
7.2
3.7
8.2
Gluten Feed
19.4
43.7
19.6
1.9
8.1
8.2
Buckwheat Middlings
23.7
37.0
13.5
4.8
7.8
13.2

feeding stuffs, we next ask, what use does the animal make of these different substances?

Water we may leave out of account, because we do not use feeding stuffs for the sake of the water which they contain.

Ash. The ash, or mineral matter, of feeding stuffs serves as a source of supply for the mineral ingredients of the body. Under ordinary circumstances the supply of ash in feeding stuffs is amply sufficient for the needs of the body and we need not concern ourselves regarding it. Occasionally, especially in feeding young animals or in cases where the ration consists very largely of grain, it is desirable to add precipitated chalk, wood ashes, or precipitated phosphate of lime to the ration.

Protein. The protein of the food is used to build up and keep in repair the working tissues of the body, which, as we have seen, consist very largely of protein. In other words, we may say that protein supplies material for the *growth of tissue.* This growth of tissue may be an actual increase in bulk, as in the case of the growing animal; it may be simply the making good of waste, as in the mature animal; it may be the growth of wool or hair; or finally, it may take the form of the production of milk, this being in reality the growth and breaking down of tissue in the udder. For all these purposes protein is indispensable, and its place cannot be taken by either carbhydrates or fat. If, however, more protein is given the animal than it needs for these various forms of tissue growth, the excess is burned up, like fat and carbhydrates as explained below, or perhaps furnishes material for the production of fat.

Fat and Carbhydrates. The uses of these two classes of substance are so similar that they may be conveniently considered together. They serve three purposes. First, they are burned to produce the heat required to keep the animal warm. Second, they are burned to produce the force exerted in the motions of the animal, somewhat as coal is burned under the boiler of a locomotive. Third, if the supply of them is greater than is needed for the production of heat and force, the excess gives rise to the production and laying up of fat in the body. It is on account of this similarity in their uses that the digestible carbhydrates and fat have been united in Table III.

But while fat and carbhydrates have substantially the same uses in the body, a given weight of fat is worth more for this purpose than the same weight of carbhydrates. One pound of fat when burned will produce, in round numbers, 2¼ times as much heat as a pound of carbhydrates; consequently, fat is 2¼ times as valuable as carbhydrates for fuel in the animal body. The same relation holds between the two as force producers and probably as fat producers.

For this reason, the digestible fat of the several feeding stuffs of Table III has been multiplied by 2¼ before adding it to the carbhydrates. In other words, the column headed "carbhydrates and fat" really shows the number of pounds of carbhydrates which are equivalent to the fat plus carbhydrates actually present.

Nutritive Ratio. We have just seen that the protein of the food serves, in the main, a different purpose in the animal economy from carbhydrates and fat. The relative amounts of these in a given feeding stuff are therefore important. This relation is expressed by what is called the "nutritive ratio," which means the ratio of digestible protein to digestible carbhydrates plus fat. Before making this comparison however, we must, as just explained, multiply the fat by 2¼, since a pound of fat is 2¼ times as valuable as a pound of carbhydrates.

This multiplication having been already made in Table III, the nutritive ratio of any feeding stuff in that table may be found by comparing the digestible protein with the digestible carbhydrates and fat. Thus, in the case of the first feeding stuff, the ratio is 1.1:12.7.

For greater convenience in comparing one feeding stuff with another, however, the first term of the ratio is usually taken as unity. We have, therefore, the following proportion:

1.1:12.7::1:11.5.

The nutritive ratio is 1:11.5; that is, there are 11.5 pounds of digestible carbhydrates and fat present for every pound of digestible protein.

Nutritive ratios are spoken of as being "wide" or "narrow." A feeding stuff with a wide nutritive ratio is one which contains a large proportion of carbhydrates and fat as compared with protein. A feeding stuff with a narrow nutritive ratio is one which contains a small proportion of carbhydrates and fat as compared with protein. Thus, comparing the example just given with the nutritive ratio of cotton-seed meal, namely, 1:1.2, we should say that the soiling corn had a wide ratio and the cotton-seed meal a narrow ratio. Of course the terms are relative. A ratio of 1:5 is a narrow ratio as compared with a ratio of 1:12, but is at the same time a wide ratio as compared with the ratio of 1:2.

Proportion of Protein needed for different Purposes. What has been said regarding the uses of the ingredients of feeding stuffs makes it plain that the proportion of protein in the food (that is, the nutritive ratio) should vary according to the purpose of the feeding. If tissue is to be built up or repaired, that is, if we are feeding for growth or for milk production, we need sufficient protein to furnish the raw material for this production. If, on the

other hand, we are feeding for the production of fat or of work we simply need enough protein to keep the animal tissues in repair, while the remainder of the food may consist of carbhydrates and fat.

We may therefore divide the purposes for which farm animals are fed into two groups, as follows:

Requiring more Protein.	*Requiring less Protein.*
Growth.	Maintenance.
Milk production.	Fattening.
(Wool production).	Work.

Feeding Standards. The statement just made, however, is not sufficiently definite for the purposes of the stock feeder. He not only needs to know that for some purposes he must supply more protein than for others, but he must know also what proportion of protein to carbhydrates and fat (that is, what nutritive ratio) is best adapted for the purpose he has in view, and he must know also *how much* food he should give.

It is not yet possible to give an answer to these questions which will apply to every case. The proper ration will vary with the kind and quality of the animals fed and with the conditions under which they are fed, including financial conditions. There is no "best" ration for fattening or for milk production, any more than there is a "best" plow or a "best" plan for a barn.

In order, however, to supply a general guide, various investigators have condensed the results of experiments and of practical experience into what are called "feeding standards." Such a standard attempts to state what is, in general, and under average conditions, a good ration for the purpose in view. It shows what has given good results with other feeders but it is not asserted that it is exactly adapted to the particular circumstances of each user. In other words, it is not a recipe, but a statement of experience.

Furthermore, in order not to limit the user to a few specific feeding stuffs, the standard is expressed, not in pounds of grain and fodder but in pounds of dry matter and of digestible protein, carbhydrates and fat. Thus, for a dairy cow weighing 1,000 pounds, the standard recommended by one investigator is as follows:

Dry matter,	24.51 lbs.
Digestible protein,	2.15 "
Digestible carbhydrates and fat,	14.94 "
Total digestible matter,	17.09 "
Nutritive ratio,	1.6.9

This means that any combination of suitable feeding stuffs containing these amounts of dry matter and of digestible matters will

be as good a ration as the average of the rations from which the standard was obtained, and will therefore correspond in essentials to the experience and practice of good dairymen. It does not mean that every dairy cow ought to be fed exactly such a ration as this, or that if she is the best results will be obtained. It is simply, as has already been said, the condensed result of experience.

In Table IV of the appendix are contained a number of feeding standards for various purposes, most of them based upon the writings of German authorities.

These standards are for animals weighing 1,000 pounds. For heavier or lighter animals it is usual to increase or diminish the computed ration in proportion to the weight, although in practice the individuality of the animal will usually be a more important factor than the live weight.

Use of Feeding Standards. Granting that the experience of others, as expressed in a feeding standard, is worth following, we may avail ourselves of it with the aid of Table III of the appendix, by the use of a little simple arithmetic. We have merely to devise a mixture out of the feeding stuffs available which shall contain the amounts and proportions of digestible matter given in the standard, and which shall have a suitable bulk, as indicated by the amount of dry matter contained in it. When using such a mixture we shall know that we are following the general experience of good feeders. We shall not know that we are feeding the very best ration which could be used under our particular circumstances, but there is every probability that a ration computed in this manner will give much more satisfactory results than are obtained from the too common haphazard feeding based simply upon the feeding stuffs which happen to be at hand or upon the market price per ton.

It is not proposed at this time to enter into the question of what are the proper standards for the various purposes of feeding, or how these standards should be varied to suit different conditions. The consideration of these questions would involve an elaborate discussion of the whole science of feeding and would require a volume for its proper treatment. The purpose of the present publication is simply, as already stated, to help farmers to use the feeding standards we already have.

PART II.

THE COMPUTATION OF RATIONS.

In Part I the general ideas upon which the use of feeding standards is based have been explained. We now proceed to take up the method of using these standards in practice.

The general problem is to devise a mixture of suitable feeding stuffs which shall correspond in the amounts of dry matter and of digestible matters which it contains to some standard which has for one reason or another been fixed upon as suitable for the purpose in view. This is purely an arithmetical problem, requiring merely a knowledge of simple arithmetic, including percentage, and a little ingenuity. It is what the mathematician calls an "indeterminate" problem; that is many mixtures of feeding stuffs might be made, all of which would correspond to a given standard. Consequently it is impossible to give any rule for the computation of rations in the same sense in which we can give a rule for computing interest. The problem can only be solved by trial and the method of doing it is best explained by examples such as those which follow, which are designed to illustrate the principal points likely to come up. The reader is urged to perform each of these examples for himself as the quickest and surest means of acquiring proficiency.

Comparison of a Ration with a Standard. Some fattening steers, averaging 1,000 pounds live weight, are being fed, per day and head,

12 pounds mixed hay.

14 pounds corn chop (corn-and-cob meal).

How does this ration compare with that recommended in Table IV for the main fattening period?

In order to make this comparison we need to compute the total amount of dry matter and the amounts of digestible matter contained in the ration. According to Table III the foods used contain the following percentages of dry matter and digestible matter:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	
Mixed hay,	85.7	4.7	42.7	47.4	1: 9.1
Corn-and cob meal,	84.9	4.4	66.5	70.9	1:15.1

Taking first the hay, we multiply 12 pounds by the percentages of the various ingredients to find the number of pounds of each of these ingredients contained in the 12 pounds of hay, as follows:

Mixed Hay.

12 lbs. x .857=10.28 lbs. of dry matter.
12 lbs. x .047= 0.56 lbs. of digestible protein.
12 lbs. x .427= 5.12 lbs. of digestible carbhydrates and fat.

Taking next the corn chop we perform the same operations, as follows:

Corn-and-cob Meal.

14 lbs. x .849=11.89 lbs. of dry matter.
14 lbs. x .044= 0.62 lbs. of digestible protein.
14 lbs. x .665= 9.31 lbs. of digestible carbhydrates.

Next, adding together the amounts of dry matter and digestible matter in the hay and the corn-and-cob meal, we have the total contained in the ration, which we may then compare with the standard.

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Twelve pounds mixed hay, ...	10.28	0.56	5 12	5.68	. . . . .
Fourteen pounds corn-and-cob meal, . . .	11.89	0.62	9.31	9.93	. . . . .
Total, ...	22.17	1.18	14.43	15.61	1:12.2
Standard, ...	26.00	3.0	16.4	19.4	1: 5.5

This comparison shows us that our ration is considerably lower in total digestible matter than the standard, and that it is especially deficient in protein, the result being that its nutritive ratio is very wide as compared with that of the standard. As already explained, this does not prove that the ration is not a suitable one for the circumstances under which it is being used. It simply shows that it does not correspond with the experience and judgment of those who proposed this particular standard.

Improvement of a Ration. A bunch of yearling steers, averaging 500 pounds each, are receiving per day and head:

20 lbs. corn silage.
2 lbs. clover hay.
4 lbs. oats.
2 lbs. corn meal.

Is it desirable to make any change in the ration?

According to Table III the feeding stuffs in use contain the following amounts of dry matter and digestible matter:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	
Corn silage,	27.9	1.1	18.2	19.3	1:16.5
Clover hay,	84.7	6.4	38.5	44.9	1: 6.0
Oats,	89.0	9.2	53.2	62.4	1: 5.8
Corn meal,	85.0	5.5	71.1	76.6	1:12.9

Making, for each feeding stuff, exactly the same calculations as were given in detail in the preceding paragraph, we have the following results as compared with the standard.

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Twenty pounds corn silage,	5.58	0.22	3.64	3.86	.....
Two pounds clover hay,	1.69	0.13	0.77	0.90	.....
Four pounds oats,	3.56	0.37	2.13	2.50	.....
Two pounds corn meal,	1.70	0.11	1.42	1.53	.....
Total,	12.53	0.83	7.96	8.79	1:9.6
Standard,	12.00	1.3	7.5	8.8	1:6.0

We thus find that the total quantity of digestible matter which is being fed corresponds closely with the standard. The difference in the amount of dry matter is likewise immaterial. The amount of protein, however, is decidedly less than that recommended in the standard, and consequently the nutritive ratio is much wider. A reference to the composition of the feeding stuffs shows us that the clover hay and oats have about the nutritive ratio of the standard, while the silage and the corn meal have a much wider ratio. Evidently, if it is desired to retain the silage in the ration, it will be necessary to replace some of the grain by something much richer in protein than either the oats or the clover. Running over the last column of Table III for such a feeding stuff, that is, one with a narrow nutritive ratio, we find, among others, cotton-seed meal, having a very narrow ratio, the figures being as follows:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	
Cotton-seed meal,	91.8	37.2	43.7	80.9	1:1.2

Replacing the two pounds of oats by the same amount of cotton-seed meal, we find that the ration stands as follows:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Twenty pounds corn silage,	5.58	0.22	3.64	3.86	
Two pounds clover hay,	1.69	0.13	0.77	0.90	
Two pounds oats,	1.78	0.18	1.06	1.24	
Two pounds corn meal,	1.70	0.11	1.42	1.53	
Two pounds cotton-seed meal,	1.84	0.74	0.87	1.61	
Total,	12.59	1.38	7.76	9.14	1:5.6
Standard,	12.00	1.3	7.5	8.8	1:6.0

It is now rather better than the standard, and while it will cost a trifle more than the first ration, there is little question that it will be much better adapted to growing animals.

Computation of a Ration from given Feeding Stuffs. The following feeds are available for constructing a ration for dairy cows, to correspond with the so-called "Wisconsin" standard:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	
Corn forage,	57.8	2.5	36.1	38.6	1:14.4
Clover hay,	84.7	6.4	38.5	44.9	1: 6.0
Corn meal,	85.0	5.5	71.1	76.6	1:12.9
Wheat bran,	88.1	12.0	45.4	57.4	1: 3.8
Gluten feed,	91.7	19.4	63.3	82.7	1: 3.3

The first step in the construction of a ration is to fix upon the amounts of coarse fodders. It is usually desirable to use as large a proportion of these as possible, since they are usually cheaper sources of food than grain. On the other hand, the amount of them which an animal can consume is limited. Much depends upon the individual animals and the proper amount can only be told by trial.

We need, according to the standard selected, a total of about 24.5 pounds of dry matter. Of this we should probably aim to get from 14 to 16 pounds in the form of coarse fodder. Corn forage being a cheap feeding stuff we shall naturally use this freely, with probably some hay for variety. By a little trial we find that 14 pounds of corn forage and 8 pounds of clover hay will give us nearly 15 pounds of dry matter and the amounts of digestible matter shown below:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0 35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
	14.87	0.86	8.13	8.99	1:9.5

To this we have to add sufficient grain to bring the ration up to the standard. The proper amount we must ascertain by trial. We will take at a venture 6 pounds of corn meal and 3 pounds of wheat bran. Adding this to the ration we have:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
Six pounds corn meal,	5.10	0.33	4.27	4.60	
Three pounds wheat bran,	2.64	0.36	1.36	1.72	
	22.61	1.55	13.76	15.31	1:8.9

Comparing these figures with the standard, we find that the ration is somewhat deficient in quantity, and that its nutritive ratio is considerably too wide. In the list of feeding stuffs available we see that the gluten feed is the one containing the largest proportion of digestible protein, and since our ration lacks protein we naturally make trial of this. We need 1.79 pounds of total digestible matter to bring the ration up to the standard. This would be almost exactly supplied by 2 pounds of gluten feed. Adding this to the ration, it stands as in the following table:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
Six pounds corn meal,	5.10	0.33	4.27	4.60	
Three pounds wheat bran,	2.64	0.36	1.36	1.72	
Two pounds gluten feed,	1.83	0.39	1.27	1.65	
	24.44	1.94	15.03	16.96	1:7.7

We now have the total amount of digestible matter right, but the nutritive ratio is still too wide. Evidently we need to use less corn and more bran and gluten feed. Reducing the corn meal by 2 pounds, and adding one pound each of bran and gluten feed we have the following:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
Four pounds corn meal,	3.40	0.22	2.84	3.06	
Four pounds wheat bran,	3.52	0.48	1.82	2.30	
Three pounds gluten feed,	2.75	0.58	1.90	2.48	
	24.54	2.14	14.69	16.83	1:6.9

The computed nutritive ratio now corresponds almost exactly with the standard. The total digestible matter is a trifle low, but the difference is too small to be significant.

By proceeding in this manner, with a little patience we can usually get a ration corresponding as closely as is necessary to the standard, provided the feeds available admit of it. With a little experience one very soon learns to guess pretty closely, and with some practice finds the computations very easy. An exact agreement with the standard need not be sought for, since in practice the composition of the feeds will probably vary more or less from the average of the tables, while the amount which the animals will eat will probably also vary more or less from that computed for them.

The Selection of Feeding Stuffs:—In the selection of feeding stuffs, one of the most frequent and important questions which arises is, which of several feeding stuffs at given prices is really the cheapest. A simple example will serve to illustrate this: A farmer has more hay on hand than he needs; shall he sell timothy hay at $12 per ton or clover hay at $8? In other words, does the higher market price of timothy hay mean that it has a correspondingly higher feeding value? From Table III we have the following figures for the actual amounts of food contained in the two.

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	
Timothy hay,	86.8	2.9	46.9	49.8	1:16.2
Clover hay,	84.7	6.4	38.5	44.9	1: 6.0

We find that timothy hay does contain more total food than clover hay, but that the difference is not at all proportionate to the difference in price. From the amounts of digestible matter contained in 100 pounds, with the prices for the same amount, it is easy to calculate the cost of one pound of digestible matter in each, as follows:

Timothy Hay.

100 pounds contain 49.8 lbs. digestible matter and cost 60 cents
60c ÷ 49.8=1.205c, cost of one pound of digestible matter.

Clover Hay.

100 pounds contain 44.9 lbs. digestible matter and cost 40 cents.
40c ÷ 44.9=0.891c, cost of one pound of digestible matter.

We thus see that the clover hay, at the assumed price, is a much cheaper source of food than the timothy. The latter has a relatively high market price owing to the special demand for it for feeding horses. Moreover, the clover is not only a cheaper source of food, but is also much richer in protein, which is usually the most expensive ingredient of feeding stuffs, either to produce or to buy. The relative fertilizing value of the timothy and clover would also enter into a consideration of the question of their sale, but this branch of the subject will be considered in a subsequent section.

More commonly the question is a question of the choice of grain feeds. For example, the following feeds are available to a dairy farmer:

Oats, ...@$15 per ton (24c. per bu).
Wheat bran, ...@ 14 per ton.
Wheat middlings, ...@ 16 per ton.
Hominy chop, ...@ 14 per ton.
Dried brewers' grains, ...@ 14 per ton.
Gluten feed, ...@ 17 per ton.
Cotton-seed meal, ...@ 20 per ton.
Old process linseed meal, ...@ 18 per ton.

The prices given above have been assumed arbitrarily and do not purport to represent present market prices, but have been chosen to illustrate the principles involved.

The first step is to see how much the actual food, that is, the digestible matter, of these feeding stuffs, costs. Taking the percentages of total digestible matter from Table III and the prices as given above, and dividing the second by the first, exactly as in the illustration with the timothy and clover hay, we get the following:

	Digestible matter in 100 lbs.	Cost of 100 lbs.	Cost of 1 pound of digestible matter.
Oats,	62.4 Lbs.	75 Cents.	1.202 Cents.
Wheat bran,	57.4 "	70 "	1.219 "
Wheat middlings,	73.7 "	80 "	1.085 "
Hominy chop,	86.6 "	70 "	0.808 "
Dried brewers' grains,	63.5 "	70 "	1.102 "
Gluten feed,	82.7 "	85 "	1.028 "
Cotton-seed meal,	80.9 "	1.00 "	1.236 "
Linseed meal (old process),	77.8 "	90 "	1.157 "

From the figures in the last column of the above table we see that hominy chop is relatively the cheapest of these feeds. Feeds like oats and wheat bran are excluded as too costly at these prices, although when the market for them rules lower they might be preferred.

We will assume that the coarse fodder on hand is sufficient to give each animal per day and head the amounts stated in the previous section, namely, 14 pounds corn forage and 8 pounds clover hay. We will assume also that we have sufficient corn on hand to give 4 pounds per day and head. With these amounts we should have the following ration:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.73	0.51	3.08	3.59	
Four pounds corn meal,	3.40	0.22	2.84	3.06	
	18.27	1.08	10.97	12.05	1:10.2

The rest of the feed required must be bought. If it were simply a question of the quantity of digestible matter needed, hominy chop would evidently be our first choice. We must consider, however, not only the total amount of feed, but also the nutritive ratio. When we take this into consideration, it is evident that we shall have to use some of the feeds richer in protein (the last four in the list) in order to "balance up" the ration, even though they are relatively more expensive, and very likely we shall find that we cannot use the hominy chop to any considerable extent in addition to corn meal. The most promising feeds for balancing up the ration appear to be dried brewers' grains and gluten feed, since they furnish food at a less cost per pound than cotton-seed or linseed meal.

To bring our ration up to the standard we still need 1.12 pounds of protein. This would be supplied, according to Table III, by about 5.5 pounds of gluten feed, or by 6.8 pounds of dried brewers' grains. The former being the cheaper source of food we will try it. Experience shows, however, that we shall need to feed with it some laxative food in order to keep the cattle in proper condition. Linseed meal will probably answer this purpose, with the added advantage that we could reduce the quantity slightly and still get the amount of protein desired. Let us try four pounds of gluten feed and one pound of linseed meal. This gives us the following ration:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
Total as above,	18.27	1.08	10.97	12.05	
Four pounds gluten feed,	3.67	.78	2.53	3.31	
One pound linseed meal,	.91	.29	.49	.78	
	22.85	2.15	13.99	16.14	1:6.5

This gives us the desired amount of protein, but the carbhydrates and fat, and therefore the total digestible matter, are still below the standard. Adding a pound of hominy chop to bring up the carbhydrates and fat, makes our ration stand as follows:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
Four pounds corn meal,	3.40	0.22	2.84	3.06	
Four pounds gluten feed,	3.67	0.78	2.53	3.31	
One pound linseed meal,	0.91	0.29	0.49	0.78	
One pound hominy chop,	0.88	0.07	0.80	0.87	
Total,	23.73	2.22	14.79	17.01	1:6.7

Our ration now corresponds substantially with the standard, but it is still a question whether we have made it up in the cheapest way possible. To test this, we may calculate the cost of one pound of digestible matter in the mixture of grains purchased, as follows:

	Digestible matter.	Cost.
	Lbs.	Cents.
Four pounds gluten feed,	3.31	3.40
One pound linseed meal,	0.78	0.90
One pound hominy chop,	0.87	0.70
	4.96	5.00

One pound digestible matter costs 5.00 cts. ÷4.96=1.008 cents.

We find that one pound of digestible matter costs us 1.008c. which is cheaper than we could buy it in the form of dried brewers' grains, and the latter are thereby excluded from consideration. There is still a possibility, however, that by using more of the cheaper foods, such as hominy chop, and balancing up the ration with a relatively small amount of linseed meal, we can make a still cheaper combination. By a little trial we find that three pounds of hominy chop and three pounds of linseed meal will also give us a ration corresponding quite closely to the standard, as follows:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Fourteen pounds corn forage,	8.09	0.35	5.05	5.40	
Eight pounds clover hay,	6.78	0.51	3.08	3.59	
Four pounds corn meal,	3.40	0.22	2.84	3.06	
Three pounds hominy chop,	2.65	0.21	2.39	2.60	
Three pounds linseed meal,	2.72	0.88	1.45	2.33	
	23.64	2.17	14.81	16.98	1:6.8

Computing as before the cost of a pound of digestible matter in the grain purchased, we have the following figures:

	Digestible matter.	Cost.
Three pounds hominy chop,	2.60 Lbs.	2.10 Cents.
Three pounds linseed meal,	2.33 "	2.70 "
	4.93 Lbs.	4.80 Cents.

One pound of digestible matter costs 4.80 cts. ÷ 4.93=0.980 cents.

We find that, notwithstanding we have used three pounds of the relatively expensive linseed meal instead of one, we have really secured a balanced ration at a slightly less cost than in the first case. The difference is not large, but it serves to illustrate the general principle that it is often cheaper to use a small quantity of a comparatively expensive feed to balance up the ration than to use a much larger quantity of a relatively cheaper feed. It is not unlikely that a still cheaper combination might be made by using cotton-seed meal instead of linseed meal, but it is doubtful whether the use of cotton-seed meal would be advisable unless silage, bran or some other laxative feed could be used with it.

This suggests the fact that other considerations than that of relative cost enter into the question of the selection of feeding stuffs.

The palatibility of a material, its general healthfulness, or any specific effects which it is known to have on the animal or on the flavor or appearance of the product, must all be taken into account. A consideration of these points in this connection, however, would lead us aside from our present purpose, which is to show how the market price should affect our choice.

Planning a Season's Feeding:—The amount of feed on hand, as well as what can be bought and the state of the markets, enters as an important factor into the fixing of the ration. The following com-

paratively simple case may serve to illustrate the method of attacking the problem. As in the previous illustration, the prices of feeding stuffs have been arbitrarily assumed and do not necessarily correspond to present market rates.

Thirty dairy cows, averaging 1,000 pounds each, are to be fed for 200 days. We have on hand:

20 tons timothy hay,	@$12 00	per ton.
10 tons clover hay,	@ 8 00	per ton.
10 tons corn stover, estimated at,	3 00	per ton.
100 tons corn silage, estimated at,	1 50	per ton.
800 bushels corn ears,	@ 14	per bu.
400 bushels oats,	@ 24	per bu.

We can buy:

Wheat bran,	@$12 00	per ton.
Wheat middlings,	@ 14 00	per ton.
Hominy chop,	@ 14 00	per ton.
Buckwheat middlings,	@ 15 00	per ton.
Old process linseed meal,	@ 18 00	per ton.
Cotton-seed meal,	@ 19 00	per ton.

Thirty cows for 200 days is equivalent to one cow for 6,000 days. The amounts of feed on hand, then, would enable us to feed per day and head the amounts given below. To facilitate comparison, the corresponding amount of dry matter, computed from the figures of Table III, is also given in each case.

	Total weight.	Dry matter.
Timothy hay,	6.67 Lbs.	5.79 Lbs.
Clover hay,	3.33 "	2.82 "
Corn stover,	3.33 "	1.99 "
Corn silage,	33.33 "	9.30 "
Total coarse fodder,	46.67 Lbs.	19.90 Lbs.
Corn ears (35 lbs. to the bushel),	4.67 Lbs.	3.96 Lbs.
Oats (32 lbs. to the bushel),	2.13 "	1.90 "
Total grain,	6.80 Lbs.	5.86 Lbs.

We find that we have rather more than enough dry matter to make up a standard ration, but that a relatively large proportion of this is in the form of coarse fodder. If, as in the previous case, we assume that we can use to advantage from 14 to 16 pounds of dry matter in the ration in the form of coarse fodder, we have more coarse fodder than is necessary. Under these circumstances a comparison of the cost per pound of digestible matter, as given in the following table, shows us at once that we can profitably sell timothy hay:

	Digestible matter in 100 lbs.	Cost of 100 lbs.	Cost of 1 lb of digestible matter.
Timothy hay	49.8 Lbs.	60 Cents.	1.205 Cents.
Clover hay	44.9 "	40 "	0.891 "
Corn stover	36.8 "	15 "	0.408 "
Corn silage	19.3 "	7½ "	0.389 "
Corn ears (corn and cob meal)	70.9 "	40 "	0.564 "
Oats	62.4 "	75 "	1.202 "
Wheat bran	57.4 "	60 "	1.045 "
Wheat middlings	73.7 "	70 "	0.950 "
Hominy chop	86.6 "	70 "	0.808 "
Buckwheat middlings	74.2 "	75 "	1.011 "
Old process linseed meal	77.8 "	90 "	1.157 "
Cotton-seed meal	80.9 "	95 "	1.174 "

If we were to sell all the timothy we should reduce our stock of coarse fodder rather low, but at the prices given it is not unlikely that even this would be economy, since the hay could be replaced by relatively cheap grain. We will suppose, however, that we can buy clover hay. We accordingly buy five tons of the latter and sell all the timothy.

20 tons of timothy hay at $12	$240 00
5 tons of clover hay at $8	40 00
Balance,	$200 00

We should then have the following stock of coarse fodder per day and head:

	Total weight.	Dry matter.
	Lbs.	Lbs.
Clover hay	5.00	4.24
Corn stover	3.33	1.99
Corn silage	33.33	9.30
Total coarse fodder	41.66	15.53

Turning now to the question of grain, we find that we have too little, but we note also that the oats at 24 cents are a much more expensive feed than any other of the grains available. It will therefore be economy to sell the oats and use the money to buy something cheaper.

Balance from sale of timothy hay, ...	$200 00
400 bushels oats at 24 cents, ...	96 00
Balance available for purchase of grain,	$296 00

We have now to determine what shall be purchased. The feed we have on hand will give us the following ration:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Five pounds clover hay, ...	4.23	0.32	1.93	2.25	.....
Three and one-third pounds corn stover, .	1.99	0.07		1.23	.....
Thirty-three and one-third pounds corn silage.	9.30	0.37	6.07	6.44	.....
Four and two-third pounds corn and cob meal.	3.96	0.20	3.11	3.31	.....
	19.48	0.96	12.27	13.23	1:12.8
Lacking to make up Wisconsin standard, .	5.02	1.24	2.63	3.87	1: 2.1

In order to bring the above ration up to the Wisconsin standard we need 3.87 pounds of total digestible matter, with a nutritive ratio of 1:2.1. Consulting Table III, we find that of the feeds available buckwheat middlings has about the proper ratio. Before deciding on this, however, it will be well to see whether, as in a former case, a still cheaper source of feed may not be found in a mixture of hominy chop and linseed or cotton-seed meal. By trial we find that a mixture of 4 pounds of linseed meal and one pound of hominy chop gives about the ratio of 1:2.1. Computing the cost of digestible matter in this mixture as compared with that in buckwheat middlings, we have the following:

	Digestible matter.	Cost.	Cost of 1 lb. of digestible matter.
Four pounds linseed meal, ...	3.112 Lb.	3.60 Cents.	.....
One pound hominy chop, ...	.866 "	0.70 "	.....
Total, ...	3.978 Lb.	4.30 Cents.	1.081 Cents.
Buckwheat middlings, ...			1.011 "

A slightly cheaper mixture might be made with cotton-seed meal, but it would still be excelled by the buckwheat middlings.

The buckwheat middlings thus proving to be the cheapest, we proceed to make up the ration with them. We lack 3.87 lbs. of digestible matter as compared with the standard. This would be almost supplied in five pounds of buckwheat middlings. Adding this, we have the following:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Five pounds clover hay, ...	4.23	0.32	1.93	2.25	. . . . .
Three and one-third pounds corn stover, .	1.99	0.07	1.16	1.23	. . . . .
Thirty-three and one-third pounds corn silage.	9.30	0.37	6.07	6.44	. . . . .
Four and two-third pounds corn and cob meal.	3.96	0.20	3.11	3.31	. . . . .
Five pounds buckwheat middlings, ...	4.34	1.19	2.52	3.71	. . . . .
	23.82	2.15	14.79	16.94	1:6.9

The ration now corresponds almost exactly to the standard except that the dry matter is a little low. This means that the ration contains a rather large proportion of grain to coarse fodder. If we could get more clover hay, it would probably be advisable to increase the amount of it in the ration somewhat and decrease that of the grain, provided the cows would eat a larger amount of coarse fodder. A glance at our table of the cost of feeding stuffs shows us that it would not pay to retain any of the timothy hay for this purpose.

Five pounds of buckwheat middlings per day for thirty cows and for two hundred days equals 30,000 pounds or fifteen tons, so that our account of receipts and expenditures will stand as follows:

Net receipts from sales of hay and oats,.....	$296 00
15 tons buckwheat middlings at $15, ...	225 00
Balance on hand, ...	$71 00

By thus virtually exchanging feeding stuffs, we have secured a fairly well-balanced ration for our cows and have $71.00 in cash left.

This statement, however, does not take account of one very important matter, namely, the fertilizing value of the feeds bought and sold. From the figures given in Table V of the appendix, we can make up the following balance sheet for the fertilizing ingredients sold and bought.

	Nitrogen.	Phosphoric acid.	Potash.
Sold off the farm—			
Twenty tons of timothy hay,	504 Lbs.	212 Lbs.	360 Lbs.
Four hundred bushels of oats,	264 "	105 "	79 "
Total,	768 Lbs.	317 Lbs.	439 Lbs.
Brought on the farm—			
Five tons clover hay,	207 Lbs.	38 Lbs.	220 Lbs.
Fifteen tons buckwheat midlings,	1,386 "	519 "	468 "
Total,	1,593 Lbs.	557 Lbs.	688 Lbs.
Gain,	825 Lbs.	240 Lbs.	249 Lbs.
Value of gain,	$99.00	$9.60	$14.45

According to this statement, there would result from the buying and selling of feed, a gain of fertility which, if purchased in the form of commercial fertilizers, would cost about $123.05. Adding this to the $71.00 saved in cash makes a total gain of $194.05.

The final gain or loss of fertility to the farm would of course depend also upon the amount of nitrogen, phosphoric acid and potash removed in the dairy products sold. Taking the most unfavorable case, viz: that in which the whole milk is sold, and assuming that our cows average 6,000 pounds of milk each per year, the loss of fertility in the milk will compare with that gained in the feeding-stuffs as follows:

	Nitrogen.	Phosphoric acid.	Potash.
Sold in the milk,	954 Lbs.	342 Lbs.	324 Lbs.
Gained in feeding-stuffs,	825 "	240 "	249 "
Net loss from farm,	129 Lbs.	102 Lbs.	75 Lbs.
Value of net loss,	$15 48	$4 08	$3 75

The fertility gained by the purchase and exchange of feeding-stuffs proves to be almost sufficient to replace the whole amount sold in the milk during the entire year, the difference amounting to only $23.31.

Moreover, the greater part of this difference falls on the nitrogen, and the loss of this element could probably be more than made good by the growth of leguminous crops, thus leaving an insignificant amount of phosphoric acid and potash to be replaced.

If the milk were manufactured on the farm and part or all of its bye-products utilized, the export of fertility would be largely decreased and the farm would be gaining in fertility.

Starting, then, with a supply of feeding-stuffs about sufficient in amount but poorly proportioned, we have been able, by judicious "swapping," to make up a good ration and at the same time to save $71.00 in cash besides securing sufficient fertility to almost make good the loss resulting from the sale of milk during the entire year.

The conditions of the above problem have purposely been assumed to be very simple, there being supposed to be only one kind of stock, which is fed the same ration throughout the season. These simple conditions have been assumed for the sake of more clearly illustrating the method of solving such a problem.

If it were thought desirable, the several feeding stuffs available could, of course, be made into two or three different rations upon the same principle, while, in case several kinds of stock are kept, the feeding stuffs on hand could first be approximately divided between them in accordance with their special requirements and then computations similar to the above made for each kind of stock. A firm grasp of the principles involved, together with some practice, will soon enable one to plan his season's feeding with a very good degree of accuracy and often, as in the above case, at a considerable saving of dollars and cents.

The Compounding of Rations. The figures given above for the various rations are not intended to suggest that each day's ration ought to be laboriously weighed out to each animal. Having fixed upon the ration, the most satisfactory plan is usually to mix the grain ration in considerable quantity in advance. Thus, in the case given, we should mix, say

467 lbs. Corn-and-cob meal and
500 lbs. Buckwheat middlings,

or as many times that quantity as might be practicable.

Then, if the grain is to be fed twice per day in equal quantities, we should weigh out the half ration of 4.8 pounds a few times until we came to know about the proper bulk and should then feed from the mixture by measure. This, with a little practice, can be done very accurately. We should also naturally vary the total amount fed to each cow according to her capacity as a milk producer.

The coarse fodder, we should distribute between the different feedings according to our best judgment. We might, for example, feed one-half the silage after milking in the morning, the hay at noon, the remaining half of the silage after milking at night and the stover (cut) the last thing at night. The amount of coarse fodder given will naturally be regulated by the appetite of the animals, but the feeder should know approximately how much his animals will eat in order to have a basis for his computation of rations. A few weighings of coarse fodder when practicable will be of much help

in enabling one to judge more accurately of the quantity eaten and will often reveal striking errors in one's estimate of it.

PART III.

THE FERTILIZING VALUE OF FEEDING-STUFFS.

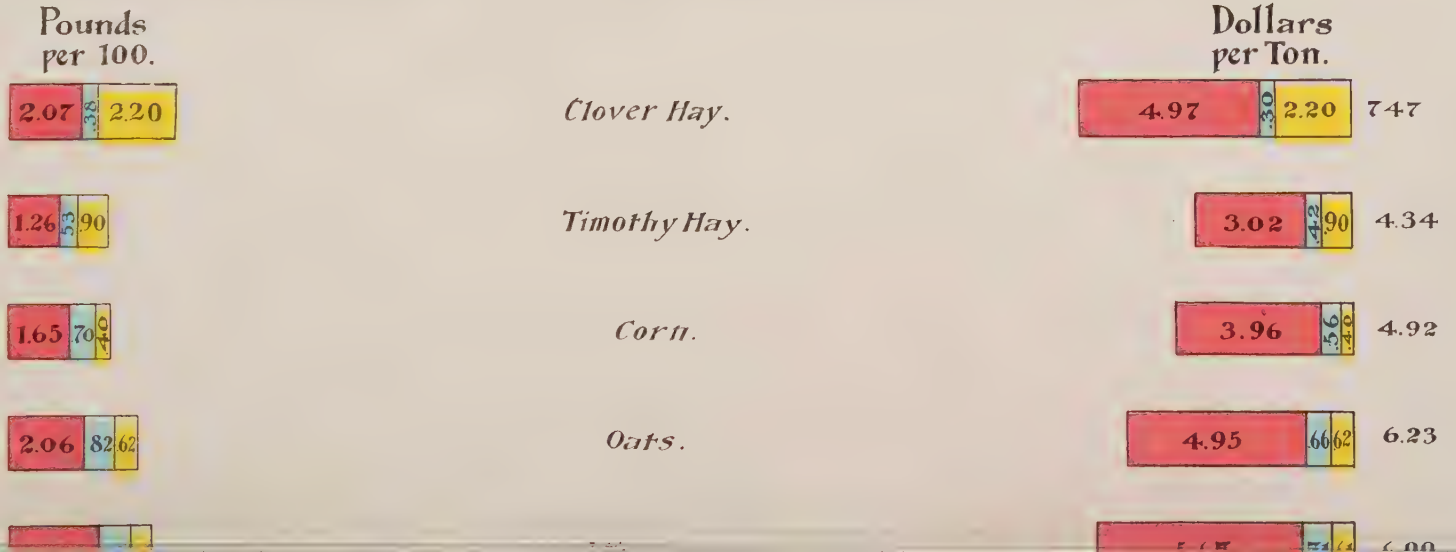
Since all feeding stuffs contain greater or less quantities of the three elements which give their commercial value to fertilizers, namely, nitrogen, phosphoric acid and potash, and since all of these substances or a very large percentage of them is recovered in the manure of the animals fed, it is plain that when we buy feeding stuffs we also buy fertility and, on the other hand, when we sell feeding stuffs, or in fact any crops, we sell fertility also. An important factor in judging of the economy of a feeding operation is the resulting gain or loss of fertility from the farm. In Table V of the appendix is given a statement, first of the number of pounds of nitrogen, phosphoric acid and potash contained in the several feeding stuffs whose composition has been given in Tables II and III, and, second, a statement of the money value of the fertility in a ton of each material, assuming nitrogen to be worth twelve cents per pound, phosphoric acid 4 cents and potash 5 cents. These values are somewhat arbitrarily assumed, since we have no satisfactory basis for fixing their commercial value, but they may, without serious error, be assumed to represent the commercial value of fertilizers of equal availability. That is, the valuations in the table mean that, for example, the nitrogen, phosphoric acid, and potash removed from the farm in a ton of winter wheat could be replaced in the form of commercial fertilizers of about the same availability for approximately $6.99.

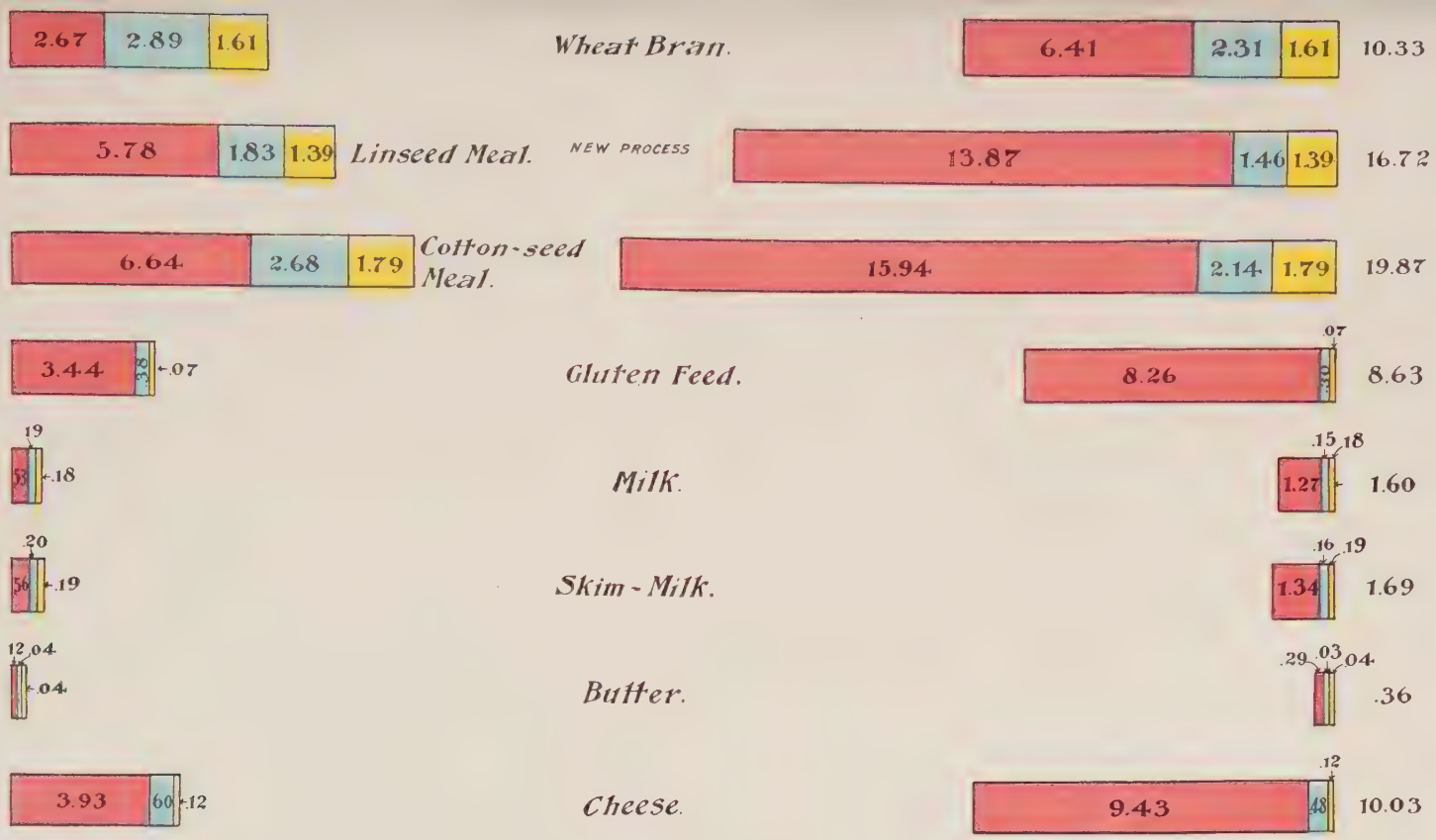
The example given in the last paragraph of Part II will serve to illustrate the manner of using these figures in connection with the computation of rations. The fertilizing value of feeds will seldom be the primary element determining their choice, but before a ration or a plan of feeding is finally decided upon it is always desirable to compute its effect upon the farm's stock of fertility. Oftentimes, a slight change in the ration may make a very material difference in this respect at very slight expense and the choice between two feeding stuffs may often be determined when in doubt by reference to their fertilizing value.

FERTILIZER VALUES.

Nitrogen. 12¢ Phosphoric Acid. 4¢ Potash. 5¢

PREPARED by the PENNSYLVANIA STATION.




2.67
2.89
1.61
Wheat Bran.
6.41
2.31
1.61
10.33
5.78
1.83
1.39
Linseed Meal.
NEW PROCESS
13.87
1.46
1.39
16.72
6.64
2.68
1.79
Cotton-seed Meal.
15.94
2.14
1.79
19.87
3.44
.38
.07
Gluten Feed.
8.26
.40
.07
8.63
.58
.19
.18
Milk.
1.27
.15
.18
1.60
.56
.20
.19
Skim-Milk.
1.34
.16
.19
1.69
.12
.04
.04
Butter.
.29
.03
.04
.36
3.93
.60
.12
Cheese.
9.43
.48
.12
10.03

APPENDIX OF USEFUL TABLES.

TABLE I.

Percentage Composition of Live Animals.

	Ox.				Sheep.					Swine.	
	Well-fed.	Half fat.	Fat.	Fat calf.	Lean.	Well-fed.	Half fat.	Fat.	Very fat.	Well-fed.	Fat.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Water, ...	54.3	50.2	43.6	60.1	56.6	53.7	50.7	44.8	39.0	53.9	42.0
Ash, ...	4.8	4.4	3.9	4.5	3.4	3.3	3.2	2.9	2.8	2.7	1.8
Fat, ...	7.1	14.9	26.8	13.1	8.6	13.2	18.3	28.1	37.2	22.5	40.2
Protein, ...	15.8	15.5	13.7	15.3	15.4	14.8	13.8	12.2	11.0	13.9	11.0
Contents of stomach & intestine,	18.0	15.0	12.0	7.0	16.0	15.0	14.0	12.0	10.0	7.0	5.0
Total, . . .	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE II.

Average Composition of Feeding Stuffs.

From Jenkins & Winton's compilation (O. E. S. Bulletin No. 11) except as otherwise noted.

	Number of analyses.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.
Soiling Fodder.							
Corn—dent, cut before glazing, . .	54	79.7	1.2	1.7	5.4	11.5	0.5
Cow pea, ...	10	83.6	1.7	2.4	4.8	7.1	0.4
Oats, ...	5	62.2	2.5	3.4	11.2	19.3	1.4
Red clover, ...	43	70.8	2.1	4.4	8.1	14.8	1.1
Rye, ...	6	82.0	1.6	2.4	4.8	8.5	0.7
Soja bean, ...	6	74.8	2.4	3.0	7.3	11.5	1.0
Silage.							
Corn silage—kernels glazing or more mature,*	14	72.1	1.4	2.1	6.7	16.4	1.3
Red clover, ...	5	72.0	2.6	4.2	8.4	11.6	1.2
Hay, Straw, Etc.							
Alfalfa hay, ...	21	8.4	7.4	14.3	25.0	42.7	2.2
Corn forage—field cured, ...	35	42.2	2.7	4.5	14.3	34.7	1.6
Corn stover†—field cured, ...	60	40.1	3.4	3.8	19.7	31.9	1.1
Clover hay—red, ...	38	15.3	6.2	12.3	24.8	38.1	3.3
Mixed hay, ...	. . . . .	14.3	5.3	9.1	26.9	41.5	2.9
Oat straw, ...	12	9.2	5.1	4.0	37.0	42.4	2.3
Orchard grass hay, ...	10	9.9	6.0	8.1	32.4	41.0	2.6
Red top hay, ...	9	8.9	5.2	7.9	28.6	47.5	1.9
Rye straw, ...	7	7.1	3.2	3.0	38.9	46.6	1.2
Timothy hay, ...	68	13.2	4.4	5.9	29.0	45.0	2.5
Wheat straw, ...	7	9.6	4.2	3.4	38.1	43.4	1.3
Roots and Tubers.							
Carrots, ...	8	88.6	1.0	1.1	1.3	7.6	0.4
Mangel wurzels, ...	9	90.9	1.1	1.4	0.9	5.5	0.2
Potatoes, ...	12	78.9	1.0	2.1	0.6	17.3	0.1
Rutabagas, ...	4	88.6	1.2	1.2	1.3	7.5	0.2
Sugar beets, ...	19	86.5	0.9	1.8	0.9	9.8	0.1
Turnips, ...	3	90.5	0.8	1.1	1.2	6.2	0.2
Grain.							
Barley, ...	10	10.9	2.4	12.4	2.7	69.8	1.8
Buckwheat, ...	8	12.6	2.0	10.0	8.7	64.5	2.2
Corn—dent, ...	86	10.6	1.5	10.3	2.2	70.4	5.0
Corn—flint, ...	68	11.3	1.4	10.5	1.7	70.1	5.
Corn—sweet, ...	26	8.8	1.9	11.6	2.8	66.8	1.8

*Partial compilation by the writer. †The stalks and leaves of corn after the removal of the ears.

TABLE II.—*Continued.*

	Number of analyses.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.
Oats,	30	11.0	3.0	11.8	9.5	59.7	5.0
Peas,	.....	14 4	2.7	22.6	5.4	53.0	1.9
Rye,	6	11.6	1.9	10.6	1.7	72.5	1.7
Sorgum seed,	10	12.7	2.1	9.0	2.6	70.0	3.6
Wheat—spring,	13	10.4	1.9	12.5	1.8	71.2	2.2
Wheat—winter,	262	10.5	1.8	11.8	1.8	72.0	2.1
Wheat—winter, raised in Pennsylvania,	41	10.7	1.6	11.8	1.7	72.2	2.0
Mill Products.							
Barley meal,	3	11.9	2.6	10.5	6.5	66.3	2.2
Buckwheat middlings,	3	13.2	4.8	28.9	4.0	42.0	7.1
Corn meal,	77	15.0	1.4	9.2	1.9	68.7	3.8
Corn-and-cob meal,	7	15.1	1.5	8.5	6.6	64.8	3.5
Pea meal,	2	10.5	2.6	20.2	14.4	51.1	1.2
Rye bran,	7	11.6	3.6	14.7	3.5	63.8	2.8
Wheat bran,	88	11.9	5.8	15.4	9.0	53.9	4.0
Wheat middlings,	32	12.1	3.3	15.6	4.6	60.4	4.0
Wheat shorts,	12	11.8	4.6	14.9	7.4	56.8	4.5
Bye-Products and Waste Material.							
Apple pomace,	7	76.7	0.5	1.4	3.9	16.2	1.3
Brewers' grains—dried,*	15	8.3	4.0	21.3	13.2	47.3	5.9
Brewers' grains—wet,	15	75.7	1.0	5.4	3.8	12 5	1.6
Corn cobs,	18	10.7	1.4	2.4	30.1	54.9	0.5
Cotton seed hulls,	4	10.4	2.6	4.0	44 4	36.6	2.0
Cott n seed meal,	35	8.2	7.2	42.3	5.6	23.6	13.1
Gluten feed,†	46	8.2	1.0	22.8	7.0	50.3	10.7
"Chicago" gluten meal,†	17	9.6	1.1	32.6	1.1	48.4	7.2
"Cream" gluten meal,†	10	7.8	1.6	37.1	1.6	34.6	17.3
Hominy chop,	.....	11.1	2.5	9.8	3.8	64.5	7.4
Linseed meal—new process,	14	10.1	5.8	33.2	9.5	38.4	3.0
Linseed meal—old process,	21	9.2	5.7	32.9	8.9	35.4	7.9
Malt sprouts,	4	10.2	5.7	23.2	10.7	48.5	1.7
Dairy Products.							
Buttermilk,	24	91.8	0.8	2.8	.....	4.3	0.3
Milk,	.....	87.3	0.7	3.1	.....	5.1	3.8
Skim milk,	303	90.5	0.8	3.5	.....	4.8	0.4
Whey,	.....	93.0	0.8	0.8	.....	5.0	0.4

* Average of J. & W's. figures and analyses by N. J. and Penna. Stations. Report N. J. Exp't Station, 1894

TABLE III.

Digestible Matter in Feeding-Stuffs.

The average American digestion co-efficients compiled by Jordan (Expt. St. Record, VI, 5,) have been used so far as possible. When American co-efficients were not available Wolff's German co-efficients (Mentzel & v. Lengerke, 1895) have been employed. In those cases in which the digestibility had to be estimated from that of other similar feeding-stuffs the figures are put in parenthesis.

	Number of analyses.	Total dry matter.	Per Cent. of Digestible Matter.			Nutritive ratio.
			Protein.	Carbhydrates and fat.*	Total.	
Soiling Fodder.						
Corn—dent, cut before glazing,	54	20.3	1.1	12.7	13.8	1:11.5
Cowpea,	10	16.4	1.6	7.5	9.1	1: 4.7
Oats,	5	37.8	(2.7)	(24.6)	(27.3)	(1: 9.1)
Red clover,	43	29.2	3.0	14.9	17.9	1: 5.0
Rye,	6	18.0	1.9	10.9	12.8	1: 5.7
Soja bean,	6	25.2	(2.3)	(11.6)	(13.9)	(1: 5.0)
Silage						
Corn silage—kernels glazing or more mature,	14	27.9	1.1	18.2	19.3	1:16.5
Red clover,	5	28.0	(2.8)	(15.3)	(18.1)	(1: 5.5)
Hay, Straw, Etc.,						
Alfalfa hay,	21	91.6	10.4	43.0	53.4	1: 4.1
Corn forage—field cured,	35	57.8	2.5	36.1	38.6	1:14.4
Corn stover—field cured,	60	59.9	2.0	34.8	36.8	1:17.4
Clover hay—red,	38	84.7	6.4	38.5	44.9	1: 6 0
Mixed hay,	...	85 7	4.7	42.7	47.4	1: 9.1
Oat straw,	12	90.8	1.4	45.9	47.3	1:32.8
Orchard grass hay,	10	90.1	4.8	45.2	50.0	1: 9.4
Red top hay,	9	91.1	4.8	49.2	54.0	1:10.3
Rye straw,	7	92.9	0.6	42.5	43.1	1:69.2
Timothy hay,	68	86.8	2.9	46.9	49.8	1:16.2
Wheat straw,	7	90.4	0.6	39.3	39.9	1:65.5
Roots and Tubers.						
Carrots,	8	11.4	(0.9)	(8.9)	(9.8)	(1: 9.9)
Mangel wurzels,	9	9.1	1.1	5.4	6.5	1: 4.9
Potatoes,	12	21.1	0.9	15.7	16.6	1:17.4
Rutabagas,	4	11.4	1.0	8.5	9.5	1: 8.5
Sugar beets,	19	13.5	1.6	10.9	12.5	1: 6.8
Turnips,	3	9.5	1.0	7.7	8.7	1: 7.7
Grain.						
Barley,	10	89.1	8.7	69.2	77.9	1: 8.0
Buckwheat,	8	87.4	(7.8)	(54.8)	(62.6)	(1: 7.0)
Corn—dent,	86	89.4	6.2	75.2	81.4	1:12.1
Corn—flint,	68	88.7	6.3	74.9	81.2	1:11.9

* The fat reduced to its starch equivalent by multiplying by 2.25.

TABLE III—*Continued.*

	Number of analyses.	Total dry matter.	Per Cent. of Digestible Matter.			Nutritive ratio
			Protein.	Carbhydrates and fat.*	Total.	
Grain—Continued.						
Corn—sweet,	26	91.2	7.0	78.4	85.4	1:11.2
Oats,	30	89.0	9.2	53.2	62.4	1: 5.8
Peas,	...	85.6	18.8	53.5	72.3	1: 2.8
Rye,	6	88.4	(6.4)	(70.3)	(76.7)	(1:11.0)
Sorgum seed,	10	87.5	(5.4)	(66.8)	(72.2)	(1:13.3)
Wheat—spring,	13	89 6	(7.5)	(70.0)	(77.5)	(1: 9.3)
Wheat—winter,	262	89.5	(7.1)	(70.5)	(77.6)	(1: 9.9)
Wheat—winter, raised in Pennsylvania,	41	89.3	(7.1)	(70.5)	(77.6)	1: 9.9
Mill Products.						
Barley meal,	3	88.1	7.4	68.8	76.2	1: 9.3
Buckwheat middlings,	3	86.8	(23.7)	(50.5)	(74.2)	(1: 2.1)
Corn meal,	77	85.0	5.5	71.1	76.6	1:12.9
Corn-and-cob meal,	7	84.9	4.4	66.5	70.9	1:15.1
Pea meal,	2	89.5	16.8	53.1	69 9	1: 3.2
Rye bran,	7	88.4	(11.5)	(48.8)	(60 3)	(1: 4.2)
Wheat bran,	88	88.1	12.0	45.4	57.4	1: 3.8
Wheat middling,	32	87.9	12.8	60.9	73.7	1: 4.8
Wheat shorts,	12	89.2	12.2	58.6	70.8	1: 4.8
Bye-Products and Waste Material.						
Apple pomace,	7	23.3	(1.1)	(16.4)	(17.5)	(1:14.9)
Brewers' grains—dried,	15	91.7	16.8	47.1	63.9	1: 2.8
Brewers' grains—wet,	15	24.3	4.3	12.8	17.1	1: 3.0
Corn cobs,	18	89.3	0.4	53.2	53.6	1:33.0
Cotton seed hulls,	4	89.6	0.4	34.9	35.3	1:87.3
Cotton seed meal,	35	91.8	37.2	43.7	80.9	1: 1.2
Gluten feed,	46	91.7	19.4	63.3	82.7	1: 3.3
"Chicago" gluten meal,	17	90.4	27.7	56.9	84.6	1: 2.1
"Cream" gluten meal,	10	92.2	32.3	72.5	104.8	1: 2.2
Hominy chop,	...	88.9	(7.1)	(79.5)	(86.6)	1:11.2
Linseed meal—new process,	14	89.9	28.9	44.9	73.8	1: 1.6
Linseed meal—old process,	21	90.8	29.3	48.5	77.8	1: 1.7
Malt sprouts,	4	89.8	18.6	40.3	58.9	1: 2.2
Dairy Products.						
Buttermilk,	24	8 2	2.8	5.0	7.8	1: 1.8
Milk,	...	12.7	3.1	13.7	16.8	1: 4.4
Skim milk,	303	9.5	3.5	5.7	9.2	1: 1 6
Whey,	...	7.0	0.8	5.9	6.7	1: 7.4

* The fat reduced to its starch equivalent by multiplying by 2.25.

TABLE IV.

Feeding Standards.

A—Per day and 1,000 pounds live weight.*

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbhydrates and fat.	Total.	
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	
Oxen at rest in stall,	17 5	0.7	8.3	9.0	1:11.9
Wool sheep, coarser breeds,	20.0	1.2	10.8	12.0	1: 9.0
Wool sheep, finer breeds,	22.5	1.5	12.0	13.5	1: 8.0
Oxen moderately worked,	24.0	1.6	12.0	13.6	1: 7.5
Oxen heavily worked,	26.0	2.4	14.3	16.7	1: 6.0
Horses lightly worked,	20.0	1.5	10.4	11.9	1: 6.9
Horses moderately worked,	21.0	1.7	11.8	13.5	1: 6.9
Horses heavily worked,	23.0	2.3	14.3	16.6	1: 6.2
Milk cows, Wolff's standard,	24.0	2.5	13.4	15.9	1: 5.4
Milk cows, Wisconsin standard,	24.5	2.2	14.9	17.1	1: 6.8
Fattening oxen, preliminary period,	27 0	2.5	16.1	18.6	1: 6 4
Fattening oxen, main period,	26.0	3.0	16.4	19.4	1: 5.5
Fattening oxen, finishing period,	25.0	2.7	16.2	18.9	1: 6.0
Fattening sheep, preliminary period,	26.0	3.0	16.3	19.3	1: 5.4
Fattening sheep, main period,	25.0	3.5	15.8	19.3	1: 4.5
Fattening swine, preliminary period,	36.0	5.0	27.5	32.5	1: 5.5
Fattening swine, main period,	31.0	4.0	24.0	28.0	1: 6.0
Fattening swine, finishing period,	23.5	2.7	17.5	20.2	1: 6.5
Growing cattle:					
Age. Months. — *Average live weight per head.*					
2—3 — 150 lbs.,	22.0	4.0	18.3	22.3	1: 4.6
3—6 — 300 lbs.,	23.4	3.2	15.8	19.0	1: 4.9
6—12 — 500 lbs.,	24.0	2.5	14.9	17.4	1: 6.0
12—18 — 700 lbs.,	24.0	2.0	13.9	15.9	1: 7.0
18—24 — 850 lbs.,	24.0	1.6	12.7	14.3	1: 8.0
Growing sheep:					
5—6 — 56 lbs.,	28.0	3.2	17.4	20.6	1: 5.4
6—8 — 67 lbs.,	25.0	2.7	14.7	17.4	1: 5.4
8—11 — 75 lbs.,	23.0	2.1	12.5	14.6	1: 6.0
11—15 — 82 lbs.,	22.5	1.7	11.8	13.5	1: 7.0
15—20 — 85 lbs.,	22 0	1.4	11.1	12.5	1: 8.0
Growing fat pigs :					
2—3 — 50 lbs.,	42.0	7.5	30.0	37.5	1: 4.0
3—5 — 100 lbs.,	34.0	5.0	25.0	30.0	1: 5.0
5—6 — 125 lbs.,	31.5	4.3	23.7	28.0	1: 5.5
6—8 — 170 lbs.,	27.0	3.4	20.4	23.8	1: 6.0
8—12 — 250 lbs.,	21.0	2.5	16.2	18.7	1: 6.5

* The fattening rations are calculated for 1,000 lbs. live weight at the beginning of the fattening.

TABLE IV.—*Continued.*

B—Per day and head.

		Dry matter.	Digestible.			Nutritive ratio.
			Protein.	Carbhydrates and fat.	Total.	
Growing cattle :		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
Age. Months.	*Average live weight per head.*					
2—3	150 lbs., . . .	3.3	0.6	2.8	3.4	1:4.6
3—6	300 lbs., . . .	7.0	1.0	4.9	5.9	1:4.9
6—12	500 lbs., . . .	12.0	1.3	7.5	8.8	1:6.0
12—18	700 lbs., . . .	16.8	1.4	9.7	11.1	1:7.0
18—24	850 lbs., . . .	20.4	1.4	11.1	12.5	1:8.0
Growing sheep :						
5—6	56 lbs., . . .	1.6	0.18	0.974	1.154	1:5.4
6—8	67 lbs., . . .	1.7	0.18	0.981	1.161	1:5.4
8—11	75 lbs., . . .	1.7	0.16	0.953	1.113	1:6.0
11—15	82 lbs., . . .	1.8	0.14	0.975	1.115	1:7.0
15—20	85 lbs., . . .	1.9	0.12	0.955	1.075	1:8.0
Growing fat swine :						
2—3	50 lbs., . . .	2.1	0.38	1.50	1.88	1:4.0
3—5	100 lbs., . . .	3.4	0.50	2.50	3.00	1:5.0
5—6	125 lbs., . . .	3.9	0.54	2.96	3.50	1:5.5
6—8	170 lbs., . . .	4.6	0.58	3.47	4.05	1:6.0
8—12	250 lbs., . . .	5.2	0.62	4.05	4.67	1:6.5

TABLE V.

Fertilizing Constituents of American Feeding Stuffs and Manurial Value per Ton.

From the Handbook of Experiment Station Work, except as otherwise noted, Nitrogen valued at 12 cents per pound, Phosphoric Acid at 4 cents and Potash at 5 cents.

	Pounds in 100 pounds.			Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
Soiling Fodder.							
Corn—dent, cut before glazing, . .	0.41	0.15	0.33	.984	.120	.33	1.43
Cow pea, ...	0.27	0.10	0.31	.648	.080	.31	1.04
Crimson clover (just heading),* . .	0.40	0.12	0.34	.960	.096	.34	1.40
Crimson clover (full bloom),*	0.51	0.12	0.35	1.224	.096	.35	1.67
Orchard grass (in bloom), ...	0.43	0.16	0.76	1.032	.128	.76	1.92
Pasture grass,*	0.75	0.19	0.60	1.	.152	.60	2.55
Red clover, ...	0.53	0.13	0.46	1.272	.104	.46	1.84
Rye, ...	0.33	0.15	0.73	.792	.120	.73	64
Soja bean, ...	0.29	0.15	0.53	.696	.120	.53	1.35
Silage.							
Corn silage—average of all analyses.	0.28	0.11	0.37	.672	.088	.37	1.13
Red clover, ...	0.53	.013	0.46	1.272	.104	.46	1.84
Hay, Straw, Etc.							
Alfalfa hay, ...	2.19	0.51	1.68	5.256	.408	1.68	7.34
Corn forage—field cured, ...	1.76	0.54	0.89	4.225	.432	.89	5.55
Corn stover—field cured, ...	1.04	0.29	1.40	2.496	.232	1.40	4.13
Clover hay—red, ...	2.07	0.38	2.20	4.968	.304	2.20	7.47
Hungarian grass hay, ...	1.20	0.35	1.30	2.880	.280	1.30	4.46
Mixed meadow grass hay,*	1.02	0.26	1.48	2.448	.208	1.48	4.14
Mixed hay, ...	1.67	0.46	1.55	4.009	.368	1.55	5.93
Oat straw, ...	.62	0.20	1.24	1.488	.160	1.24	2.89
Orchard grass hay, ...	1.31	0.41	1.88	3.144	.328	1.88	5.35
Red top hay, ...	.15	0.36	1.02	2.760	288	1.02	4.07
Rye straw, ...	0.46	0.28	0.79	1.104	.224	.79	2.12
Timothy hay, ...	1.26	0.53	0.90	3.024	.424	.90	4.35
Wheat straw, ...	0.59	0.12	0.51	1.416	.096	.51	2.02
Wheat chaff, ...	0.79	0.70	0.42	1.896	.560	.42	2.88
Roots and Tubers.							
Carrots, ...	0.15	0.09	0.51	.360	.072	.51	.94
Mangel wurzels, ...	0.19	0.09	0.38	.456	.072	.38	.91
Potatoes, ...	0.21	0.07	0.29	.504	.056	.29	.85
Rutabagas, ...	0.19	0.12	0.49	.456	.096	.49	1.04
Sugar beets, ...	0.22	0.10	0.48	.528	.080	.48	1.09
Turnips, ...	0.18	0.10	0.39	.432	.080	.39	.90

*Report N. J. Exp't Station, 1894.

TABLE V—*Continued.*

	Pounds in 100 pounds.			Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total
Grain.							
Barley,	1.51	0.79	0.48	3.625	.632	.48	4.74
Buckwheat,	1.44	0.44	0.21	3.456	.352	.21	4.02
Corn—dent,*	1.65	0.70	0.40	3.961	.560	.40	4.92
Corn—flint,*	1.68	0.70	0.40	4.033	.560	.40	4.99
Corn—sweet,*	1.82	0.72	0.41	4.369	.576	.41	5.36
Oats,	2.06	0.82	0.62	4.945	.656	.62	6.22
Peas,	3.08	0.82	0.99	7.393	.656	.99	9.04
Rye,	1.76	0.82	0.54	4.225	.656	.54	5.42
Sorgum seed,	1.48	0.81	0.42	3.553	*.648	.42	4.62
Wheat—spring,	2.36	0.70	0.39	5.665	.560	.39	6.62
Wheat—winter,	2.36	0.89	0.61	5.665	.712	.61	6.99
Mill Products.							
Barley meal,	1.55	0.66	0.34	3.720	.528	.34	4.59
Buckwheat middlings,†	4.62	1.73	1.56	1.109	1.38	1.56	14.03
Corn meal,	1.58	0.63	0.40	3.792	.504	.40	4.70
Corn-and-cob meal,	1.41	0.57	0.47	3.384	.456	.47	4.31
Pea meal,	3.08	0.82	0.99	7.392	.656	.99	9.04
Rye bran,	2.32	2.28	1.40	5.568	1.824	1.40	8.79
Wheat bran,	2.67	2.89	1 61	6.408	2.312	1.61	10 33
Wheat middlings,	2.63	0.95	0.63	6.312	.760	.63	7.70
Wheat shorts,*	2.42	1-38	0.65	5.808	1.104	.65	7.56
Rye Products and Waste Material.							
Apple pomace,	0.23	0.02	0.13	.552	.016	.13	.70
Brewers' grains—dried,	3.05	1.26	1.55	7.322	1.008	1.55	9.88
Brewers' grains—wet,	0.89	0.31	0.05	2.136	.248	.05	2.43
Cerealine feed,*	1.69	1.25	0.67	4.056	1.000	.67	5.73
Corn oil meal *	3.96	1.45	0.17	9.504	1.160	.17	10.83
Corn cobs,	0.50	0.06	0.60	1.200	.048	.60	1.85
Cotton seed hulls,	0.75	0.18	1.08	1.800	.144	1.08	3.02
Cotton seed meal,	6.64	2.68	1.79	15.936	2.144	1.79	19.87
Gluten meal,	5.03	0.33	0.05	12.072	.264	.05	12.39
Gluten feed,	3.44	0.38	0.07	8.256	.304	.07	8.63
Chicago gluten meal,*	5.52	0.29	0.05	13.248	.232	.05	13.53
Grano gluten feed,*	4.96	0.66	0.20	11.904	.528	.20	12.63
Germ meal,	3.48	6.16	2.91	8.352	4.928	2.91	16.19
Linseed meal—new process,	5.78	1.83	1.39	13.872	1.464	1.39	16.73
Linseed meal—old process,	5.43	1.66	1.37	13.032	1.328	1.37	15.73
Malt sprouts,	3.55	1.43	1.63	8.520	1.144	1.63	11.29

* Report N. J. Exp't Station, 1894.

† The nitrogen from Jenkins & Winton's compilation of analyses of American Feeding Stuffs (O. E. S. Bulletin No. 11). The phosphoric acid and potash computed on the assumption that the total ash has the same composition as that found by v. Wolff (Aschen-Analysen, II, 22) for buckwheat bran.

TABLE V.—*Continued.*

	Pounds in 100 pounds.			Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
Dairy Products.							
Butter	0.12	0.04	0.04	.288	.032	.04	.36
Buttermilk	0.48	0.17	0.16	1.152	.136	.16	1.45
Cheese	3.93	0.60	0.12	9.432	.480	.12	10.03
Cream	0.40	0.15	0.13	.960	.120	.13	1.21
Milk	0.53	0.19	0.18	1.272	.152	.18	1.60
Skim milk	0.56	0.20	0.19	1.344	.160	.19	1.69
Whey	0.15	0.14	0.18	.360	.112	.18	.65

DRIED BREWERS' GRAINS.

BY HENRY PRENTISS ARMSBY.

The Station has lately received two samples of dried brewers' grains, a feed which is attracting considerable attention since the processes for drying have been so improved as to be practicable and economical.

One of the samples was sent by Mr. J. F. Blocher, of Spring Hill, Bradford county, and the second was forwarded at Mr. Blocher's request by Mr. L. Brauns, of New York city, Mr. Brauns being the proprietor of the "Otto Patent" for a grains drying machine. The results of the analyses of these two samples are given below, together with the average of eight analyses made at the New Jersey Experiment Station and representing the product of four different companies:

	Mr. Blocher's Sample.	Mr. Braun's Sample.	Average of New Jersey analyses.
Water,	7.36	7.84	9.50
Ash,	5.62	2.73	3.83
Protein,	23.69	24.81	21.53
Crude fibre,	13.91	13.50	13.82
Nitrogen-free Extract,	43.68	44.52	45.01
Fat,	5.74	6.60	6.31
	100.00	100.00	100.00

It will be seen that there is a substantial agreement between the composition of the sample sent by Mr. Blocher and that sent by Mr. Braun, as well as of these two with the New Jersey average. It would appear from the above that the feed as purchased by Mr. Blocher was of good average quality.

In the manufacture of beer, it is the effort of the brewer to convert the starch contained in the barley or other grain used, first into sugar and then into alcohol, without removing any other material from the grain. As a consequence, the resulting grains contain larger percentages of every other ingredient, notably of protein. As regards their percentage of the later ingredient the dried grains are quite similar to peas, but on the other hand, they contain nearly three times as much woody fibre as peas and correspondingly less starchy matter. In appearance and physical properties they resemble oats or barley, but are richer in protein. Owing to their richness in portein, they can be judiciously used to balance up a ration deficient in this ingredient and are therefore of special value for milk

production and probably for growth. At $14 per ton, the price reported by Mr. Blocher, they would constitute a relatively cheap grain feed.

The New Jersey Station has experimented upon their use in place of oats for work horses with very favorable results. When used instead of oats, pound for pound, in a mixed feed with bran and corn, they gave quite as good results as oats. That Station prints the following table, showing the equivalent value of dried brewers' grains and oats:

Table of Equivalents.

Dried Brewers' Grain.	Oats.
$18 per ton	27 cts. per bu.
19 " "	28½ " " "
20 " "	30 " " "
22 " "	33 " " "
24 " "	36 " " "

The value of wet brewers' grains for milch cows has been almost universally recognized, the chief objection to their use being the readiness with which they ferment and decay and the danger of thus introducing undesirable ferments into the milk. These objectionable features are of course absent from the dried grains, while direct experiments, also made at the New Jersey Station, have shown that they are practically just as valuable for milk as are the wet grains.

SPONTANEOUS COMBUSTION OF HAY.

BY GEORGE C. WATSON.

The question of spontaneous combustion in fodder stuffs has received considerable attention from agriculturists from time to time, and has been discussed in the agricultural literature of the day as supposed cases have arisen. Nearly all the supposed cases have originated where considerable quantities of clover hay have been stored, either in stacks or barns, and in nearly every case the stacks or buildings have been consumed, so it was impossible to sufficiently understand the circumstances of the cases to determine whether they were of spontaneous or incendiary origin. A recent fire, supposed to be of spontaneous origin, occurred in a hay mow in one of the College barns, without damaging the barn to any great extent and without consuming very much of the hay. The following detailed account will enable the reader to form some opinion as to the origin of this fire.

In the evening of October 16th, 1895, fire was seen to be dropping from the ceiling of the cow stable underneath the east wing of the College barn. A general alarm of fire was sounded and immediately a sufficient force of men assembled to prevent the fire from breaking out. Investigation soon proved the fire to be confined to a mow of hay 18x23 feet and about 23 feet high, which occupied a part of the wing over the cow stable mentioned. Precautions were taken to exclude all drafts of air from the hay mow by filling the holes burned through the floor over the cow stable with wet blankets and cloths, and also keeping the top of the mow covered with wet blankets. It was believed at this time that the only means of saving the whole barn from burning was to remove the mow of hay that was already on fire. Consequently openings were made in the side of the barn and the whole mow of hay, about thirty tons, was pitched out. While removing the hay, which all through the center of the mow was smouldering and ready to burst out in flames when exposed to a draft of air, it was found necessary to keep the top of it constantly wet. Fortunately, a hose from a nearby hydrant and pails in the hands of students afforded ample means of keeping the top of the mow constantly saturated, which prevented the hay in the barn from bursting into flames, and also prevented the hay that was thrown out of the mow from burning. All of the central portion of the mow was thoroughly compacted, hot and smoking. The high temperature of the hay made it decidedly uncomfortable for those

who were working to save the barn from burning by removing this smouldering fodder. The continued application of water on the surface of the mow alone made this possible on account of the excessive heat. Not until all this lot of hay was removed from the barn was the danger from fire thought to be over. The floor of the barn on which this mow of hay rested is constructed of two thicknesses of wide inch boards so placed as to perfectly break joints. This floor forms the ceiling over the cow stable and is about eleven feet high. The holes burned through the floor were over the middle of the stable and not near partitions or posts. From the position of these holes burned through the floor, it would seem improbable if not impossible for the origin of the fire to have been either accident or incendiary. The side of the barn is of matched lumber; this undoubtedly averted a serious loss by fire by preventing anything like a draft to supply air to the hay already on fire.

There was corn fodder to the depth of about a foot at the bottom of the mow underneath the hay. The hay was second growth clover and timothy, mostly clover, quite fine, and when harvested was thought to be in unusually fine condition. The fine quality of the hay, height of the mow and the fact that nearly all of this hay was put in the mow with a horse fork and dropped from a considerable height, all were potent factors in thoroughly compressing this mow of hay. Adjoining this mow was another filled with corn fodder, the two being separated only by a cross beam and the divisions that would naturally be made by filling at different times. An examination of the pile of damaged hay after being thrown out of the barn showed that a large portion of it was so thoroughly charred that it would crumble when handled. Some of the hay had not been subjected to so great a heat and was only brown in color, but wholly unfit for stock food. The larger portion of this body of hay was subjected to so great a heat that the whole amount was nearly a total loss. It was thought to be impracticable to separate the small amount of bright hay from the damaged portions as the two were pretty thoroughly mixed in removing the hay from the barn. The insurance company paid for 23 tons at $11.00 per ton.

For several days previous to the fire, a peculiar odor had been noticed about the barn, and a somewhat careful examination was made to ascertain its source. The result of this examination seemed to indicate that the rowen in this mow was heating but no indication of fire was seen or even suspected. This odor was noticed not only by men working about the barn, but by other persons who had occasion to pass on the leeward side within forty or fifty rods of the barn. The odor was so strong that it was observed by many people and compared by some to that of burning grain. While positive proof as to the origin of this fire may be lacking, the circumstances are such that it seems safe to consider it of spontaneous origin.

A TEST OF HAND SEPARATORS.

BY HARRY HAYWARD.

The following is a summary of the results of an experiment made to compare the efficiency of several hand separators placed at this Station by their manufacturers:

(1). These trials show very little, if any, difference in completeness of skimming and the total amount of fat recovered in the cream between the different makes of separators used in the test.

(2.) With one exception, all the separators fulfilled the claims of their manufacturers as to capacity and efficiency of skimming.

(3.) All the separators used in the trial did satisfactory work under a far wider range of conditions than is recommended by the manufacturers.

(4.) Considerable difference seemed to exist between the various separators as to substantialness and durability.

(5.) That there is a wide difference in the ease with which the various separators were operated.

(6.) That the cheaper and newer machines did as efficient work in these trials as the older and more expensive ones.

(7.) That there is no difference in the quality of cream delivered by the various machines.

(8.) That there is no difference in the churnability of cream from the separators used in these tests.

(9.) That these trials would seem to indicate that the choice of a hand separator should be influenced very largely by its first cost and its apparent durability.

DETAILS OF THE EXPERIMENT.

The falling price of butter of late years, together with the general demand for a better product, has impressed upon the private dairyman the fact that if he does not have conditions necessary for the best results with the shallow pan or deep-setting systems of creaming, he is not getting as much out of his business as he should, and that, if he is to successfully compete with the progress of the times, he must adopt some different method of creaming his milk. An improvement over the old way on the dairy farm has in most cases been found in the hand separator. That the separator offers many advantages over any other system for creaming milk under ordinary conditions, when time, labor, feeding value of the skimmed milk, and the quality and quantity of the cream and

butter are considered, is admitted by all. While this is true, there are still other advantages afforded by the hand separator which as yet have received but little attention from the dairyman. Among these may be mentioned the preventing of the transmission of infectious diseases in skimmed-milk. A large number of the cattle in dairy districts are affected with tuberculosis, and it is not without reason to suppose that to a greater or less extent the milk brought to a central creamery is contaminated with tuberculous germs. The skimmed milk is all run into a common vat from which the patrons draw in common, so that any infection which may be brought to the creamery in one patron's milk is quite apt to be taken home in the skimmed milk by every other patron sooner or later. The writer is familiar with a case where a breeder of Guernsey cattle had his cows tested for tuberculosis and all of them were pronounced free from the disease. The calves of the same herd that were being fed upon creamery skimmed milk, were tested at the same time and three were found to be tuberculous. It is quite reasonable to conclude that these calves became infected with the tuberculous germ which the skimmed milk brought from the creamery, as a large number of the cows supplying milk to this creamery were afterward found to be badly affected with tuberculosis. According to our best authorities it is unquestionably true that more or less tuberculosis is distributed by the affected skimmed milk of a central creamery. Perhaps the time will come when the skimmed milk will be pasteurized at the creamery or the patron will separate his own milk and take only the cream to the creamery. What has been said of tuberculosis is also true of the undoubted infection which takes place when skimmed milk is carried back to the farm in the same cans used to carry the whole milk to the creamery. It is very difficult to keep milk cans perfectly pure and clean which are saturated from day to day with badly-cared-for skimmed milk, and especially on the farm where it is so often impracticable to have the use of live steam. This source of infection is one of the greatest against which the creameryman has to contend and one which would be entirely obviated if the new milk were skimmed on the farm.

Another objectionable feature of the creamery business which the hand separator quite effectually overcomes is the hauling of the whole milk to the creamery and the hauling of the skimmed milk back again. This amounts to a great deal in large dairies and especially when the roads are in bad condition. This great amount of hauling is entirely unnecessary and more satisfactory results with the skimmed milk could be obtained, in feeding calves especially, if the milk were separated on the farm instead of being taken to a creamery, allowed to stand for some time in the swill tank and become partially decomposed before being carried back to the farm,

there to be fed to young, growing stock which should have warm, sweet skimmed milk.

With these points in mind, together with a number of inquiries received from different parts of the State as to which of the various separators on the market (differing quite markedly in price) is the best, the Experiment Station has made a comparative test of several of the more prominent hand separators. The machines used in the experiment were the "Baby De Laval No. 3," capacity 675 pounds per hour, price $200.00, and the "De Laval Humming Bird, No. 0," capacity 175 pounds per hour, price $65.00, manufactured by the De Laval Separator Co., 74 Cortlandt street, New York; the United States No. 5," capacity 270-350 pounds per hour, price $125.00, and "Midget No. 7," capacity 180-220 pounds per hour, price $75.00, manufactured by the Vermont Farm Machine Co., Bellows Falls, Vermont; the "Mikado," capacity 200 pounds per hour, price $75.00, and the "Empire No. 5," capacity 400 pounds per hour, price $125.00, manufactured by D. H. Burrell & Co., Little Falls, N. Y., and the "National," capacity 300 pounds per hour, price $100.00, manufactured by the National Dairy Machine Co., Newark, N. J.

All of these machines were sent directly from the manufacturers and were run according to the directions sent with them. The separators were operated in each and every case by the writer, assisted by the Station creameryman, Mr. J. T. Buckwalter, to whom much credit is due for his faithfulness in assisting with this work.

The milk used was taken direct from the Station herd, consisting of grade Guernseys, and used before it had time to cool below separating temperature. The tests began March 18th, 1896, and were continued with more or less interruptions throughout the year. The cows were nearly all fresh at the beginning of the tests and of course some had nearly completed their period of lactation by the time the tests were finished, and as a consequence their milk would perhaps, at the end, skim harder than the milk used at the beginning of the trials. This was, at least in a measure, compensated for by the fact that all the cows were fed green food or ensilage during the later tests, which would perhaps have a slight tendency to make the milk less viscous and easier to skim.

The length of the runs was usually about one-half hour, or about the time which would probably be occupied in separating on a dairy farm. The capacity was estimated by measuring the time required to separate all the milk used in each trial, which was carefully weighed in each case. The efficiency of the separation was based upon the percentage of fat of the whole milk recovered in the cream, and upon the per cent. of butter fat left in the skimmed milk. Samples were drawn from all the whole milk, skimmed milk and cream by the Scovell aliquot sampler, for analysis by the Babcock method, and by thus checking up the work any error or loss

in butter fat could easily be detected. The weighing was all done on a set of platform scales which were not graduated closer than one-half pound; where so many weighings were necessary and so many samples drawn the liability for errors was so great that weights which would check up to a hundredth of a pound could not be expected.

The analysis of all samples were made by Mr. M. E. McDonnell, assistant chemist of the Station, except those obtained from "Baby" No. 3, which were made by Mr. W. S. Sweetser, also assistant chemist of the Station.

In general, the mechanical operation of the separators was all that could be desired. The machines were operated by hand and, so far as was possible without a dynamometer, comparisons made as to the ease with which the various styles of separators were operated, which will be referred to later. So far as could be observed there was no difference in the quality of cream from the different separators. All the creams appeared to be uniform in smoothness and all were delivered in a satisfactory manner with one or two exceptions, which will be noted in the tables.

Twelve tests were made with each machine (except the United States No. 5, with which but ten were made) six of which were made under conditions considered most favorable and six under conditions that were unfavorable to close skimming, inasmuch as the temperature was made much lower or the speed slower than is recommended by the manufacturer.

UNITED STATES—NO. 5.

This separator left some cream in the bottom and on the outside of the inner cone of the bowl which could not be flushed out, but the amount of fat unaccounted for in this machine was but a trifle more than the average gain or loss of all of the machines in the test. This machine, as well as the No. 7 of the same make, runs very steadily, more so than any other separator in the test, and an admirable feature of its construction is that all the cog wheels are enclosed, thus preventing the possibility of their catching anything that might be used about them.

There does not seem to be the difference between the favorable and unfavorable conditions in the efficiency of creaming that would naturally be expected, there being but .04 per cent. difference in the per cent. of fat in the skimmed milk. This would indicate that this machine at least is well adapted to varying conditions of milk and that it will do good work under a varying manner of operation. The cream separated under the unfavorable as well as the favorable conditions was delivered in a satisfactory manner.

United States Separator No. 5 –Favorable Conditions.

Date.	Pounds milk used.	Per cent. fat in milk.	Separating temperature. Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream pounds.	Total fat in skim milk—pounds.	Total fat—gain or loss—pounds.	Per cent. of total fat recovered in the cream.
March 19,	230.	4.7	90.	48.	372.9	14.3	33.	31.0	194.	.17	10.81	10.23	.32	.25—	94.6
March 20,	230.	4.8	88.	48.	352.8	15.4	35.5	30.0	189.5	.2	11.04	10.65	.37	.02—	96.4
March 21,	164.	4.8	90.	48.	364.2	10.3	17.	43.	144.	.25	7.87	7.31	.41	.15—	92.8
March 23,	204.5	4.2	89.	47.5	366.	15.6	32.	27.	170.5	.08	8.58	8.64	.13	.19+	100.6
March 24,	205.	4.9	87.	47.5	366.6	15.8	32.5	29.1	171.	.14	10.04	9.45	.23	.35—	94.1
March 27,	231.	4.8	86.5	52.	369.6	16.8	39.0	26.8	190.5	.15	11.08	10.45	.28	.35—	94.3
	210.9	4.69	88.4	48.5	365.3	14.9	31.5	30.01	176.6	.16	9.9	9.45	.29	.16—	95.4

United States Separator No. 5—Unfavorable Conditions.

March 30, A. M.	213.	4.9	89.	37.5	364.	20.6	44.	22.1	168.	.09	10.33	9.72	.15	.46—	94.
April 1, A. M.,	245.	5.3	66.	52.	376.8	18.1	44.5	28.6	199.	.12	12.98	12.72	.23	.03—	97.9
April 1, P. M.,	225.	5.35	72.	52.	364.8	17.3	39.	28.75	184.25	.14	12.03	11.21	.25	.57—	93.1
April 2, P. M.,	164.	5.35	69.	48.	339.	19.2	31.5	25.3	131.25	.14	8.77	7.97	.18	.61—	90.8
	211.7	5.2	74.	47.3	361.1	18.7	39.75	26.1	170.6	.119	11.02	10.4	.20	.42—	94.5

MIKADO.

The "Mikado" is a comparatively new machine on the market and will undoubtedly attract more or less attention from the private dairyman, inasmuch as it is one of the cheapest in first cost. As will be noticed from the tables, this separator did excellent work under the most favorable conditions, both as measured by the amount of fat left in the skimmed milk and by the proportion of fat recovered in the cream.

Under unfavorable conditions, however, the work was not so satisfactory. With a temperature of 65 degrees F. the cream was not delivered freely, but it would clog in the pan, where it was partially churned. With a temperature of 74 degrees F. the cream was delivered in good condition and with a reduced capacity the machine did work that was satisfactory. This separator is a very small machine for its capacity, but is not as substantial as some of the other separators in the test and has the disagreeable feature of making considerable noise while running.

Mikado Separator—Favorable Conditions.

Date.	Pounds of milk used.	Per cent. fat in milk.	Separating temperature Degrees	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken	Weight of cream pounds.	Per cent. fat in cream	Weight of skim milk pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream pounds.	Total fat in skim milk—pounds.	Total fat—gain or loss—pounds.	Per cent of total fat recovered in the cream
April 3, A. M., ...	158.5	5.15	86.	54.	229.	23.3	37.	21.1	120.5	.1	8.16	7.80	.12	.23—	95.5
April 3, P. M., ...	164.75	5.25	86.	54.	222.	10.9	18.	46.0	146.	.12	8.64	8.28	.17	.19—	95.8
April 4, A. M., ...	145.	5.35	87.	54.	223.	20.3	29.5	25.	117.	.1	7.75	7.37	.11	.27—	97.6
April 11, A. M., ...	150.	4.85	89.	52.	225.	16.5	24.75	29.3	124.5	.09	7.27	7.25	.11	.09+	99.7
April 11, P. M., ...	152.5	5.4	85.5	53.	215.	16.5	25.25	31.75	126.5	.13	8.23	8.01	.16	.05—	97.3
April 13, P. M., ...	155.	5.3	93.	54.	224.	16.4	25.5	32.5	128.5	.09	8.21	8.23	.11	.18+	100.8
	154.29	5.21	87.7	53.5	223.	17.2	28.66	29.3	127.1	.102	8.04	7.83	.13	.08—	97.3

Mikado Separator—Unfavorable Conditions.

April 14, A. M., ...	154.75	4.7	92.	40.	218.	16.6	25.75	27.0	128.	.19	7.27	6.95	.24	.08—	95.5
April 15, A. M., ...	143.5	4.85	89.	44.	220.	16.7	24.0	28.5	118.5	.1	6.95	6.84	.11	.001—	98.4
April 15, P. M., ...	113.5	5.35	65.	52.	226.	10.1	11.5	48.0	101.5	.5	6.07	5.52	.50	.05—	90.9
April 17, P. M., ...	62.	5.05	74.	58.	186.	15.7	9.75	29.2	51.75	.09	3.13	2.84	.04	.25—	90.7
April 18, A. M., ...	75.25	4.8	68.	52.	180.6	15.2	11.5	29.2	63.5	.1	3.61	3.35	.06	.20—	98.3
April 20, A. M., ...	76.75	4.6	67.5	60.	184.2	13.6	11.5	29.0	64.25	.09	3.52	3.33	.05	.14—	94.6
	104.29	4.88	75.9	51.	202.4	15.0	15.66	30.6	87.9	.18	5.09	4.80	.16	.13—	94.3

UNITED STATES NO. 7—"MIDGET."

It is noticeable in the trials with the U. S. No. 7 that there is but little difference in its efficiency under favorable and unfavorable conditions. The manner in which it skims cold milk and its efficiency at a low rate of speed is much to its credit. The bowl of this machine left no cream worth mentioning that could not be flushed out. It ran with almost no noise and, like No. 5 of the same make, the gearings are all enclosed.

United States Separator Midget No. 7— Favorable Conditions.

Date	Pounds of milk used.	Per cent. fat in whole milk.	Separating temperature. Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk—pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream—pounds.	Total fat in skim milk—pounds.	Total fat — gain or loss.	Per cent. of total fat recovered in the cream.
April 20, P. M.,	81.	4.8	93.	52.	194.4	14.1	11.5	31.75	68.75	.08	3.88	3.65	.05	.18—	94.
April 22, A. M.,	138.75	4.8	88.	50.	200.4	17.4	24.25	27.4	113.	.09	6.66	6.64	.1	.08+	99.6
April 22, P. M.,	144.5	5.13	87.	52.	196.8	17.3	25.	29.5	118.	.1	7.41	7.37	.11	.07+	99.4
April 23, P. M.,	160.25	5.2	91.	48.	196.2	18.0	29.0	27.5	129.75	.08	8.33	7.97	.1	.26—	95.6
April 24, A. M.,	147.5	4.65	90.	48.	196.2	15.9	23.5	28.75	123.5	.1	6.85	6.75	.12	.02+	98.5
April 24, P. M.,	160.75	5.4	87.	48.	198.6	18.9	30.5	27.75	129.75	.11	8.68	8.46	.14	.08—	97.4
	138.79	5.02	89.3	49.6	197.1	17.2	23.95	28.41	113.79	.098	6.96	6.80	.103	.057—	97.6

United States Separator Midget No. 7—Unfavorable Conditions.

April 25, A. M.,	127.	4.85	88.	40.	197.4	19.8	25.25	23.5	101.	.1	6.15	5.93	.1	.12—	96.4
April 27, A. M.,	132.75	4.6	89.	40.	193.8	18.6	24.75	23.8	106.75	.1	6.10	5.89	.1	.11—	96.5
April 27, P. M.,	128.75	5.2	76.	48.	198.	19.2	24.75	26.25	103.	.1	6.69	6.49	.1	.09—	97.0
April 28, A. M.,	149.75	4.75	75.	52.	199.2	16.6	25.0	27.1	123.5	.11	7.11	6.77	.13	.20—	95.2
April 29, A. M.,	81.	4.6	73.	48.	126.	12.9	10.5	32.6	69.5	.08	3.72	3.42	.05	.24—	91.9
April 29, P. M.,	79.	5.0	76.5	52.	157.8	13.9	11.	34.1	67.5	.09	3.95	3.75	.06	.14—	94.9
	116.37	4.82	79.5	46.6	178.7	17.2	20.20	26.59	95.20	.094	5.62	5.37	.09	.19—	95.6

DE LAVAL "BABY" NO. 3.

The most noticeable features in the trial of the "Baby No. 3," is the variation in the per cent. of fat in the cream of different runs under the same conditions.

This machine handled cold milk in a very creditable manner so far as delivery of the cream was concerned, but left a larger amount of fat in the skimmed milk than would have been the case under favorable conditions.

It will be observed that on the average of all the tests a slightly larger percentage of the fat was apparently recovered in the cream under the unfavorable conditions than under the favorable conditions. The difference, however, is less than one per cent. of the total amount of fat and is altogether too small to be of any real significance, so that this result does not contradict the conclusions drawn from the percentage of fat left in the skimmed milk.

Alpha De Laval Baby No. 3, Favorable Conditions.

Date.	Pounds of milk used.	Per cent. fat in milk.	Separating temperature Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk—pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream—pounds.	Total fat in skim milk—pounds.	Total fat—gain or loss.	Per cent. of total fat recovered in the cream.
November 30, A. M.	217.2	4.75	84.	42.	723.6	11.7	25.5	37.1	191.	0.1	10.31	9.46	.19	.66—	91.7
November 30, P. M.	165.	5.9	85.	41.	640.8	15.3	25.	31.6	127.25	0.05	8.15	7.90	.06	.19—	96.9
December 5, A. M.	237.	4.1	86.5	42.	686.4	10.0	23.75	41.3	212.5	00.	9.73	9.80	.09	.07+	100.7
December 5, P. M.	168.25	5.9	91.	42.	654.6	11.6	18.5	40.0	139.25	0.1	7.91	7.40	.139	.37—	93.5
December 7, P. M.	190.	4.8	91.	43.	685.8	12.0	19.75	40.8	142.75	0.07	7.82	8.05	.09	.32+	102.9
December 10, A. M.	118.25	4.4	89.	43.	675.6	9.9	11.75	42.0	106.	.25	5.20	4.93	.265	.00	94.8
	176.20	4.64	87.7	42.	677.8	11.7	20.7	38.0	154.79	.079	8.18	7.87	.123	.19—	96.1

Alpha De Laval Baby No. 3—Unfavorable Conditions.

December 8, A. M.	221.	4.6	88.	33.	672.6	15.5	34.5	27.4	185.5	0.10	10.13	9.45	.185	.54—	92.8
December 8, P. M.	162.	4.9	87.	36.	649.8	15.8	25.75	31.6	135.25	.25	7.96	8.13	.33	.50+	102.2
December 9, A. M.	220.	4.4	71.	42.	671.4	13.1	29.0	32.6	191.	.15	9.72	9.45	.28	.01+	96.2
December 10, P. M.	155.	4.8	61.	41.	669.	13.3	23.75	34.6	153.5	.4	8.56	8.21	.61	.26+	95.9
December 10, A. M.	95.2	4.3	55.	42.	519.5	9.1	8.75	44.0	86.25	.5	4.09	3.85	.43	.19+	94.1
December 11, A. M.	125.	4.2	58.	41.	606.	9.2	11.5	45.8	112.5	.4	5.25	5.26	.45	.46+	100.3
	167.20	4.55	70.	39.	631.3	13.2	22.20	33.28	144.0	.26	7.62	7.39	.380	.15+	97.0

EMPIRE NO. 5.

The "Empire" hand separator is another comparatively new machine, and like the "Mikado" is comparatively cheap in purchase price. In the operation of it, however, one could not fail to notice that it lacks substantialness, which would count against it for a durable machine. The noise which it makes is excessive and disagreeable as compared with the other machines. Its work in the test was satisfactory and especially its efficiency in skimming cold milk. The cream was delivered in a smooth condition and in a satisfactory manner. It is also noticeable that this machine did nearly as good work under adverse conditions as under conditions that were favorable.

Empire No. 5—Favorable Conditions.

Date.	Pounds of milk used.	Per cent. fat in milk.	Separating temperature. Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk—pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream—pounds.	Total fat in skim milk—pounds.	Total fat — gain or loss.	Per cent. of total fat recovered in the cream.
May 19, A. M.,	243.75	5.0	93.	48.	471.6	13.1	32.0	35.65	208.75	.1	12.18	11.40	.20	.58—	93.5
May 19, P. M.,	230.5	5.13	93.	46.	468.6	13.8	32.0	35.0	195.5	.11	11.82	11.20	.21	.41—	94.8
May 20, A. M.,	221.25	5.0	92.	48.	465.6	13.4	29.75	35.75	186.25	.12	11.06	10.63	.22	.21—	96.1
May 21, P. M.,	226.25	5.25	90.5	48.	460.2	14.1	32.0	34.5	193.5	.11	11.87	11.04	.21	.62—	93.0
May 22, A. M.,	224.25	5.1	90.0	44.	473.4	14.1	31.75	34.75	191.25	.13	11.43	11.03	.24	.16—	96.5
May 22, P. M.,	239.75	5.1	93.	48.	463.8	16.5	34.	35.6	205.	.1	12.22	12.10	.20	.08+	99.0
	230.95	5.09	91.9	47.	467.2	13.8	31.91	35.1	196.70	.108	11.76	11.23	.21	.32—	95.4

Empire No. 5—Unfavorable Conditions.

May 25, A. M.,	227.75	5.05	91.5	40.	455.4	15.6	35.5	30.9	195.25	.12	11.50	10.96	.23	.31—	95.3
May 26, A. M.,	153.	5.0	92.0	36.	436.8	16.6	25.5	29.0	127.25	.12	7.65	7.39	.15	.11—	96.6
June 9, A. M.,	194.	5.5	74.5	48.	465.	13.9	27.0	37.0	166.	.14	10.67	9.99	.23	.45—	93.6
June 9 P. M.,	149.25	4.6	71.5	51.	471.	12.8	19.25	34.75	129.25	.1	6.86	6.63	.12	.06—	97.3
June 10, A. M.,	165.5	4.7	72.5	48.	381.6	11.7	19.5	38.35	146.	.11	7.77	7.50	.16	.11—	96.5
June 11, A. M.,	143.75	5.2	73.	48.	405.6	11.4	17.0	40.7	129.5	.12	7.73	6.80	.15	.68—	87.9
	173.04	5 02	79.1	45.0	435.9	13.8	23.96	34.1	148.8	.116	8.69	8.22	.17	.30—	94.7

THE "HUMMING BIRD."

The "Humming Bird" separator is a small machine intended for dairies of from two to five cows. Instead of turning with a crank as do the other machines, it is run by pulling a strap which re-coils after each pull. It can be fastened to any table and the operator, seated in a chair, can easily run it. Like the De Laval "Baby No. 3," it shows a high rate of efficiency, but it does not separate its full rated capacity per hour. The work under favorable and unfavorable conditions was entirely satisfactory. With the "Humming Bird" separator it was necessary to rate its efficiency entirely upon the per cent. of fat left in the skimmed milk, for with such small quantities of milk, weighed upon scales not more delicate than those used, any variation, even within the limits of error, would be misleading.

Humming Bird Separator—Favorable Conditions.

Date.	Pounds of milk used.	Per cent. fat in milk.	Separating temperature. Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk—pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream—pounds.	Total fat in skim milk—pounds.	Total fat—gain or loss.	Per cent. of total fat recovered in the cream.
June 20, P. M.,	72.	5.25	93.5	60.	157.	11.1	8.	50.	63.5	.1	3.78	.4	.06	.28+	.....
June 22, A. M.,	71.75	5.05	92.	60.	156.	13.9	10.	38.0	60.5	.09	3.62	3.8	.05	.23+	.....
June 22, P. M.,	56.5	4.95	94.	60.	153.6	13.2	7.5	39.4	48.5	.12	2.79	2.95	.05	.21+	.....
June 23, A. M.,	69.5	5.0	89.	60.	136.8	16.5	11.5	30.25	57.	.08	3.47	3.47	.04	.04+	.....
June 23, P. M.,	55.25	5.1	91.	60.	165.6	16.2	9.	32.4	45.75	.09	2.81	2.91	.04	.14+	.....
June 24, A. M.,	57.0	4.95	89.	60.	151.8	13.1	7.5	34.25	49.25	.08	2.82	2.56	.03	.23+	.....
	63.66	4.26	91.4	60.	153.4	14.	8.9	36.5	54.08	.083	3.21	3.28	.045	.115+	.....

Humming Bird Separator—Unfavorable Conditions.

June 24, P. M.,	50.25	5.45	88.5	48.	150.6	18.9	9.5	28.3	40.25	.09	2.73	2.68	.03	.02—	.....
June 25, A. M.,	55.	5.25	89.	52.	156.	20.8	11.5	23.8	42.5	.11	2.88	2.73	.04	.10—	.....
June 25, P. M.,	62.25	5.1	90.	48.	148.8	18.4	11.5	28.5	50.	.12	3.19	3.27	.06	.14+	.....
June 26, A. M.,	59.25	5.4	69.	60.	154.2	14.5	8.5	35.	50.	.13	3.19	2.97	.06	.16—	.....
June 26, P. M.,	59.	4.8	67.	60.	152.2	18.6	11.	25.5	47.5	.13	2.83	2.80	.06	.03+	.....
June 27, A. M.,	49.25	4.75	65.	64.	155.	14.7	7.25	30.75	41.25	.1	2.33	2.22	.04	.07—	.....
	55.8	5.14	78.	55.3	153.1	17.6	9.86	28.13	45.2	.106	2.85	2.77	.048	.032—	.....

NATIONAL.

The "National" separator is a machine placed upon the market within the past year. Its attractive features are its cheapness and its ease of operation. It is the smallest machine for its capacity of any the writer has seen, but quite strongly put together. The tests of this machine were not so satisfactory as those of the others, inasmuch as the bowl vibrated a little, and the bowl rings were apparently made of such poor material that the bowl would leak unless the utmost care was exercised. It will be noticed that this separator did nearly as effectual work under unfavorable conditions as when the conditions were favorable, and in both cases the results obtained were satisfactory.

National Separator—Favorable Conditions.

Date.	Pounds of milk used.	Per cent. fat in milk.	Separating temperature. Degrees.	Revolutions of crank per minute.	Pounds separated per hour.	Per cent. of cream taken.	Weight of cream—pounds.	Per cent. fat in cream.	Weight of skim milk—pounds.	Per cent. fat in skim milk.	Total fat in whole milk—pounds.	Total fat in cream—pounds.	Total fat in skim milk—pounds.	Total fat — gain or loss.	Per cent. of total fat recovered in the cream.
July 17, A. M., ...	149.75	5.4	88.	51.5	304.	17.3	26.	28.75	122.75	.09	8.08	7.47	.11	.50—	92.4
July 17, P. M., ...	140.25	5.05	93.	54.	311.	14.9	21.	32.0	119.25	.08	7.08	6.72	.09	.27—	95.
July 18, A. M., ...	154.75	5.4	89.	53.3	319.	18.4	28.5	29.0	127.25	.1	8.35	8.26	.12	.03+	98.9
July 25, P. M., ...	131.5	4.95	91.	56.	328.	19.9	26.25	24.0	104.5	.1	6.50	6.30	.1	.1 —	96.9
July 26, A. M., ...	154.	5.2	89.	56.	307.	15.2	23.5	31.5	129.5	.1	8.00	7.40	.12	.48—	92.5
July 27, A. M., ...	164.25	5.15	93.5	54.	307.	18.7	30.75	27.0	132.75	.09	8.45	8.30	.11	.04	98.2
	149.08	5.19	90.5	54.1	312.6	17.44	26.0	28.49	122.6	.088	7.74	7.40	.108	.232—	95.6

National Separator—Unfavorable Conditions.

July 27, P. M., ...	131.5	4.8	91.	40.	297.6	23.7	31.25	19.5	99.	.....	6.31	6.09	.09	.13—	96.5
July 28, A. M., ...	131.	4.9	93.	44.	280.2	26.8	35.25	17.0	94.5	.12	6.41	5.99	.11	.31—	93.4
July 29, A. M., ...	141.25	5.1	93.	48.	302.	23.7	33.5	20.6	107.5	.11	7.20	9.20	.11	.19—	95.8
July 29, P. M., ...	74.	4.6	72.	52.	277.	15.5	11.5	28.25	63.	.09	3.40	3.24	.05	.11—	95.2
July 30, A. M., ...	68.	4.35	69.	52.	165.6	13.9	9.5	30.6	58.	.09	2.95	2.90	.05	.00	98.3
July 30, P. M., ...	70.	5.3	70.	52.	300.	17.1	12.	29.0	57.5	.16	3.71	3.48	.09	.14—	93.8
	102.6	4.87	81.3	48.	270.4	21.61	21.61	21.50	79.9	.104	4.99	4.76	.083	.147—	95.3

In the following tables are given the averages of all the separtors used in these trials under both favorable and unfavorable conditions. It will be noticed that while five of the machines have a lower percentage of fat in the skimmed milk than the average, three are below the average in per cent. of total fat recovered in the cream, which goes to show that there are other considerations to be observed in the purchase of a separator than the percentage of fat left in the skimmed milk.

It is likewise to be noted that while there is a difference of .04 in the per cent. of fat left in skimmed milk between the favorable and unfavorable conditions, there is but one per cent. of difference in the total amount of fat recovered in the cream.

Summary.—Favorable Conditions.

Name of Separator	Pounds of milk used.	Per cent. fat in milk.	Separating temperature. Degrees.	Revolution of crank per minute.	Pounds separated per hour	Per cent. of cream taken.	Per cent. fat in cream.	Per cent fat in skim milk.	Per cent. of total fat recovered in cream.
United States No. 5,	210.9	4.69	88.4	48.5	365.3	14.9	30.01	.16	95.4
Mikado,	154.29	5.21	87.7	53.5	223.	17.2	29.3	.102	97.3
U. S. Midget No. 7,	138.7	5.02	89.3	49.6	197.1	17.2	28.4	.09	97.6
Alpha Baby No. 3,	176.2	4.64	87.7	42.	677.3	11.7	38.0	.079	96.1
Empire No. 5,	230.9	5.09	91.9	47.	467.2	13.8	35.1	.108	95.4
Humming Bird,	63.66	4.26	91.4	60.	153.4	14.0	36.5	.083	.....
National,	149.0	5.19	90.5	54.1	312.6	17.44	28.49	.08	95.6
	160.52	4.96	89.5	50.6	342.3	15.09	31.75	.106	96.1*

Summary.—Unfavorable Conditions.

United States No. 5,	211.7	5.2	74.	47.3	361.1	18.7	26.1	.119	94.3
Mikado,	104.2	4.88	75.9	51.	202.4	15.0	30.6	.18	94.3
U. S. Midget No. 7,	116.3	4.82	79.5	46.6	178.7	17.2	26.59	.09	95.6
Alpha Baby No. 3,	167.2	4.55	70.	39.	631.3	13.2	33.28	.26	97.0
Empire No. 5,	173.04	5.02	79.1	45.0	435.9	13.8	34.1	.116	94.7
Humming Bird,	55.8	5.14	78.	55.3	153.1	17.6	28.13	.106	.....
National,	102.6	4.87	81.3	48.	270.4	21.61	21.5	.104	95.3
	132.97	4.92	76.8	47.4	318.9	16.45	28.52	.146	95.1*

* Not including the Humming Bird.

So far as these trials go there is a greater efficiency under a wide variation than is generally supposed. These results should not lead any operator of a hand separator to relax his vigilance in securing the best conditions possible, but go to show that where the most favorable circumstances do not exist the separator is more efficient than the other systems used for creaming milk under ordinary conditions.

EASE OF OPERATION.

One of the most important features to be considered in the purchase of a machine is the ease with which it can be operated and especially is this true if the separator is to be operated by hand, as is and will be the case in many instances. Between the separators used in these trials there was a wide difference in this respect. Without a dynamometer it was impossible to definitely state the power required to operate the different machines, and the best that can be done under the circumstances is to give a comparison of the strength required to operate each separator so far as can be judged from the actual operation of each machine for several runs.

As nearly as could be judged, the following list shows the arrangement of the various separators according to ease of operation per 100 pounds capacity.

National.
De Laval Baby No. 3 or Mikado.
Empire.
Humming Bird.
U. S. No. 5.
U. S. No. 7.

It was found, other things being equal, that a machine requiring 45 revolutions per minute turns with much less fatigue than one requiring 45 to 50 revolutions, even though the power actually required was more than in the latter case.

CHURNABILITY OF CREAM.

The statement has been made by some separator manufacturers that there is a difference in the churnability of the cream from different separators under the same conditions. In order to test this assertion eighteen trials were made in churning the cream from different separators under the same conditions. The U. S. No. 5 was adopted as a standard and the others used (the De Laval, Empire and Mikado) compared with it.

The milk used in these trials was separated as nearly as possible under the same conditions. The cream was then tested for fat and enough skimmed milk added to the richer to make its percentage of fat equal to that of the poorer one. Equal amounts of each were then weighed out and set side by side to ripen. The churnings were made the following day in the same churn, with the following results:

It will be observed that the difference between the percentage of fat left in the buttermilk, with three or four exceptions, is within the limits of error, and that, according to these results, there is practically no difference in the churnability of the cream obtained from different hand separators. A careful examination of the butter made in these churnings showed no difference in texture or flavor that could be detected, the butter being to all appearances similar in every respect.

Churnability of Cream.

Date.	Name of Separator.	Per cent. acidity in cream at churning.	Temperature at starting of the churn—Degrees.	Time required for churning—Minutes.	Temperature when butter gathered—Degrees.	Per cent. fat in the buttermilk.
June 23,	U. S. No. 5,	.623	49	29	56	.12
June 23,	Baby No. 3,	.601	48	28	56	.11
June 24,	U. S. No. 5,	.586	48	26½	57	.11
June 24,	Baby No. 3,	.559	48	23	56	.12
June 25,	U. S. No. 5,	.547	50	40	56	.12
June 25,	Baby No. 3,	.538	50½	41	58	.20
June 26,	U. S. No. 5,	.784	58	9	62	.7
June 26,	Empire,	.757	59	8½	62	.8
June 27,	U. S. No. 5,	.698	56	22	60	.4
June 27,	Empire,	.714	54	30	58	.25
June 30,	U. S. No. 5,	.549	51	31	58	.12
June 30,	Empire,	.603	50	33	56	.12
July 1,	U. S. No. 5,	.507	52	22	58	.3
July 1,	National,	.561	51	26	58	.6
July 2,	U. S. No. 5,	.658	55	17	59	.25
July 2,	National,	.626	54	16	59	.45
July 3,	U. S. No. 5,	.538	56	13	62	.13
July 3,	National,	.538	58	11	63	.13

GOUDA CHEESE.

BY HARRY HAYWARD.

The question is ever arising with the progressive dairyman, "Is there not some other product which I can make at least a part of the year that will yield me a greater profit than butter?" In the summer months butter becomes very cheap and, as there are now so many winter dairies, packed butter does not command the price that it formerly did, hence there is little else to do at present but to sell the butter for what it will bring at the time of its manufacture. For a few months of the year the return for time and labor must necessarily be very small, unless some other outlet can be found for the milk that is usually manufactured in cheap butter. In European countries the milk is turned into many forms for consumption, and it is not unreasonable to suppose that the time will come when the American dairyman will diversify his industry more to meet the demands of the home market.

America annually imports about ten million pounds of cheese valued at between two and three million dollars. Most of this imported cheese retails at a price which puts it beyond the reach of many, and if there could be found a cheese that could be made by the dairyman himself in a reasonable length of time, of small size, quick curing and palatable, it would doubtless fill a long-felt want to the cheese consumers, as well as diversify the industry. At present the writer is unfamiliar with any cheese of the above description that is made on the dairy farms of the State, and any inquiry for a dairy cheese is usually answered by a detailed description of the Cheddar process, which, for many reasons, is not adapted to the home dairy. During the latter part of the season of 1896, the Experiment Station made a few observations along the lines of a dairy cheese, and, although it is intended to carry the investigations farther the coming spring and summer, a brief description of the Gouda Cheese, its process of manufacture and results obtained with it, is not thought out of place at this time.

Gouda cheese was made in and takes its name from a town in Southern Holland. It is made from whole milk and weighs from eight to ten pounds when cured. In the manufacture of this cheese, fresh, sweet milk that has been produced and cared for in the best possible manner is used. If the cows are sick, feverish, or off feed, it is better to use the milk for some other purpose than cheese making as such milk is almost sure to produce poor cheese.

It is well to strain the milk directly into the cheese vat and to stir gently to allow the animal odor to escape as much as possible. When

ready to begin work the temperature of the milk should be from 86--88 degrees. The coloring matter should now be added at the rate of about one ounce of Hansen's color to 1,200 pounds of milk. This is done by putting the amount of color into a dipperful of milk and thoroughly stirring it into the vat of milk. The rennet should be added when the milk has reached a constant temperature of 86--88 degrees, six ounces of Hansen's rennet to 1,000 pounds of milk being the proper amount. This should start the coagulation in about 12 minutes and make it ready for cutting in about 18 or 20 minutes.

The rennet should be carefully measured out and added to a dipperful of water at the temperature of the milk, which should be stirred into the milk.

When the curd will break clean over the fingers it is ready for the knife, and a little practice will soon teach one when the curd cuts to the best advantage. It should not become so firm that it will cut hard by gathering in front of the knife or swaying off to one side, as this causes uneven cutting; neither should it be cut too soft, as this occasions too great loss of fat in the whey; yet the general tendency of the curd should be toward softness.

The cutting is done similarly to that of the Cheddar process except that it is cut finer. In this preliminary work the vertical knife alone was used, with good results. After cutting lengthwise of the vat the curd is allowed to stand until it begins to be separated from the whey and then the cutting may proceed. Cut crosswise and lengthwise alternately until the cubes of curd are about the size of peas. All curd sticking to the sides and bottom of the vat should now be removed by running the hand around the sides and bottom of the vat. After this is done the curd should be stirred very gently with both hands for about five minutes to allow the curd to heal over a little to prevent the fat from escaping. The heat is now applied, very slowly at first, either by running warm water around the vat or steam turned into hot water under the vat, and the curd heated to 104 degrees, which should require about 30 minutes.

During the heating the curd should be stirred constantly and especially should the corners be watched and no curd should be allowed to mat. After reaching 104 degrees the curd should lie in the whey until it has a sort of mealy appearance when rubbed between the thumb and finger. Draw the whey (which should be perfectly sweet) and fill the moulds at once without salting. Care should be taken to keep the curd as warm as possible while the moulds are being filled and when full it is a good plan to set the moulds in a pail of warm whey for a minute or two. In filling the moulds the curds should be put in small quantities and pressed firmly but gently with the hand. After the mould is full, take the cheese out, turn it and replace it other-side-up, put the cover on and put it under the press with slight pressure for two or three hours.

The press is a very simple and inexpensive affair, consisting of two pieces of plank about three and one-half feet long, stood on end and about two feet apart, with a short piece nailed across the top. This is set about two feet from the wall. 2x4 scantling about 12--14 feet long with one end under a block nailed to the side of the building, with a pail of stone on the other end, supplies the pressure.

After being in the press for two or three hours the cheese should be taken out of the press and dressed. This is done by taking a linen band about four inches wide and wrapping it around the cheese so that the ends will fully meet. There will then be a bare space on either side which should be covered with a linen cap to extend down to and over the linen bandage. The cheese should now be put in the mould, reversed from the way it was taken out, and put to press for about twenty-four hours or until the moulds are needed again. The pressure should be made greater by moving the weights over toward the end of the scantling.

The next day the cheese is taken from the press, the bandage removed and the cheese is ready for salting.

The salting may be done in one of two ways; either by putting the cheese in a very strong brine for three or four days and keeping the exposed surface covered with salt or by rubbing the cheese with dry salt every day for four or six days, depending upon the market.

There was some difficulty found in salting in brine, as the cheese was likely to be slimy on the outside. This is almost entirely overcome by dry-salting and, in-so-far as these observations go, dry-salting seemed to give the best results. In dry-salting very fine salt should be used and each cheese rubbed thoroughly for five minutes each day for from three to five days. After the cheese is salted it should be washed with warm water and dried with a clean linen towel and placed in the curing room shelves to be turned and rubbed every day.

One of the best places to cure a Gouda cheese is in a cool, damp cellar with a temperature of from 60 to 70 degrees. With this temperature and a fair degree of moisture, the cheese will cure and be salable in six weeks to two and one half months. If the cheese becomes moldy or slimy during the process of curing it should be scraped off and washed with warm water.

Owing to a large percentage of moisture in Gouda cheese the yield is very good. In these preliminay trials 100 pounds of milk, testing about 5 per cent. fat, yielded 14 pounds of green cheese. The amount this will cure out will depend somewhat on circumstances. Some experimenters state that in two months the cheese would lose about 17.5 per cent. of its weight.

As yet not enough of these cheeses have made to determine their market value. Those made in the preliminary period sold for the same price the Cheddar cheese was bringing at retail.

6—22—96

THE CALCULATION OF THE TOTAL SOLIDS OF MILK.

BY MILTON E. McDONNELL.

The relation existing between the amount of fat, solids not fat and water in milk is such as to make it possible to calculate the per cent. of total solids or solids not fat from the fat content and lactometer reading (which gives the specific gravity of milk). Several formulas by which this calculation can be made are used at the present time. The following is the most recent formula of Hehner and Richmond.*

$$T=0.2625\frac{G}{D}+1.2\ F.$$

T represents total solids, G the reading of the Quevenne lactometer and D the specific gravity. The specific gravity is the same as the Quevenne lactometer reading if we place the figures 1.0 before the lactometer reading.

Example.—The lactometer reading 32 is the same as 1.032 specific gravity. In the following table are given the total solids in milk as calculated by the above formula. To obtain the total solids in any milk from the table determine the per cent. of fat by the Babcock test. Determine the Quevenne lactometer reading at 60 degrees F. If the temperature is not 60 degrees the reading must always be corrected by adding .1 to the lactometer reading for each degree above 60 and subtracting .1 for every degree below 60; e. g., if the reading at 56 degrees is 31.6 the corrected reading should be about 31.6+.4=32 at 60 degrees, or if the reading is 32.1 at 64 degrees the corrected reading at 60 degrees will be about 32.4 minus .4=32. The temperature should not vary more than 10 degrees either way from 60 because the above correction is not absolutely accurate and wider variations introduce too great an error. If the New York Board of Health lactometer is used the reading must be multiplied by .29 to give the Quevenne reading which is used in this table.

Example.—New York Board of Health lactometer reading 12° multiplied by .29 34.8, which is the corresponding Quevenne reading.

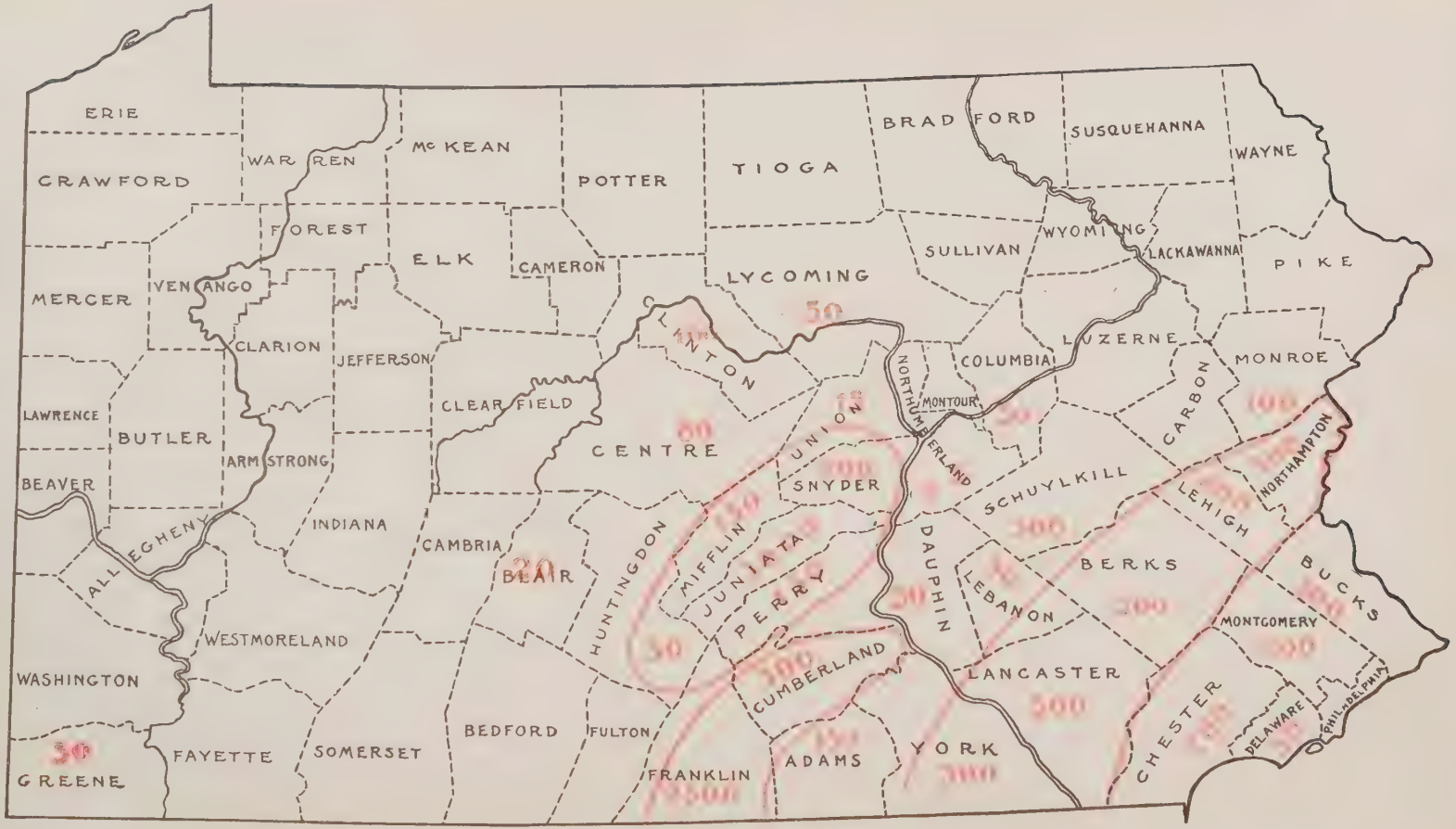
To use the table find in the first vertical column the number corresponding to the per cent. of fat. Follow this horizontal column to the column at the top of which is the lactometer reading corresponding to the reading of the milk under consideration. For an increase of every tenth in the lactometer reading at the top of the column add .025 per cent. to the result found in the table.

*Wiley's Principles and Practice of Agricultural Analysis, Vol. 3, page 479.

Example.—Let the fat content be 4.3 per cent. and the lactometer reading be 32.8. By finding 4.3 in the first vertical column and following this out to the column headed by 32 lactometer reading we find the corresponding total solids to be 13.30. For 32.8 this reading must be increased by 8 times .025=.20 per cent or the correct percentage of total solids for the above example would be 13.50 per cent.

Table Showing Per Cent. of Total Solids in Milk Corresponding to Quevenne's Lactometer Reading and Per Cent. of Fat.

Per cent. of fat.	Lactometer Reading at 60 F.											
	25	26	27	28	29	30	31	32	33	34	35	36
0.0	6.39	6.64	6.89	7.14	7.39	7.64	7.89	8.14	8.39	8.64	8.89	9.14
0.1	6.51	6.76	7.01	7.26	7.51	7.76	8.01	8.26	8.51	8.76	9.01	9.26
0.2	6.62	6.88	7.13	7.38	7.63	7.88	8.13	8.38	8.63	8.88	9.13	9.38
0.3	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	9.25	9.50
0.4	6.87	7.12	7.37	7.62	7.87	8.12	8.37	8.62	8.87	9.12	9.37	9.62
0.5	6.99	7.24	7.49	7.74	7.99	8.24	8.49	8.74	8.99	9.24	9.49	9.74
0.6	7.11	7.36	7.61	7.86	8.11	8.36	8.61	8.86	9.11	9.36	9.61	9.86
0.7	7.23	7.48	7.73	7.98	8.23	8.48	8.73	8.98	9.23	9.48	9.73	9.98
0.8	7.35	7.60	7.85	8.10	8.35	8.60	8.85	9.10	9.35	9.60	9.85	10.10
0.9	7.47	7.72	7.97	8.22	8.47	8.72	8.97	9.22	9.47	9.72	9.97	10.22
1.0	7.59	7.84	8.09	8.44	8.59	8.84	9.09	9.34	9.59	9.84	10.09	10.34
1.1	7.71	7.96	8.21	8.46	8.71	8.96	9.21	9.46	9.71	9.96	10.21	10.46
1.2	7.83	8.08	8.33	8.58	8.83	9.08	9.33	9.58	9.83	10.08	10.33	10.58
1.3	7.95	8.20	8.45	8.70	8.95	9.20	9.45	9.70	9.95	10.20	10.45	10.70
1.4	8.07	8.32	8 57	8.84	9.07	9.32	9.57	9.84	10.07	10.34	10.57	10.84
1.5	8.19	8.44	8.69	8.96	9.19	9.44	9.69	9.96	10.19	10.44	10.69	10.96
1.6	8.31	8.56	8.81	9.08	9.31	9.56	9.81	10.08	10.31	10.56	10.81	11.08
1.7	8.43	8.68	8.93	9.18	9.43	9.68	9.93	10.18	10.43	10.68	10.93	11.18
1.8	8.55	8.80	9.05	9.30	9.55	9.80	10.05	10.30	10.55	10.80	11.05	11.30
1.9	8.67	8.92	9.17	9.42	9.67	9.92	10.17	10.42	10.67	10.92	11.17	11.42
2.0	8.79	9.04	9.29	9.54	9.79	10.04	10.29	10.54	10.79	11.04	11.29	11.54
2.1	8.91	9.16	9.41	9.66	9.91	10.16	10.41	10.66	10.91	11.16	11.41	11.66
2.2	9.03	8.28	9.53	9.78	10.03	10.28	10.53	10.78	11.03	11.28	11.53	11.78
2.3	9.15	9.40	9.65	9.90	10.15	10.40	10.65	10.90	11.15	11.40	11.65	11.90
2.4	9.27	9.52	9.77	10.02	10.27	10.52	10.77	11.02	11.27	11.52	11.77	12.02
2.5	9.39	9.64	9.89	10.14	10.39	10.64	10.89	11.14	11.39	11.64	11.89	12.14
2.6	9.51	9.76	10.01	10.26	10.51	10.76	11.01	11.26	11.51	11.76	12.01	12.26
2.7	9.63	9.88	10.13	10.38	10.63	10.88	11.13	11.38	11.63	11.88	12.13	12.38
2.8	9.75	10.00	10 25	10.50	10.75	11.00	11.25	11.50	11.75	12.00	12.25	12.50
2.9	9.87	10.12	10.37	10.62	10.87	11.12	11.37	11.62	11.87	12.12	12.37	12.62
3.0	10.00	10.24	10.49	10.74	10.99	11.24	11.49	11.74	11.99	12.24	12.49	12.74
3 1	10.11	10.36	10.61	10.86	11.11	11.36	11.61	11.86	12.11	12.36	12.61	12.86
3.2	10.23	10.48	10.73	10.98	11.23	11.48	11.73	11.98	12.23	12.48	12.73	12.98
3.3	10.35	10.60	10.85	11.10	11.35	11.60	11.85	12 10	12.35	12.60	12 85	13.10
3.4	10.47	10.72	10.97	11.22	11.47	11.72	11.97	12.22	12.47	12.72	12.97	13.22
3.5	10.59	10.84	11.09	11.34	11.59	11.84	12.09	12.34	12.59	12.84	13.09	13.34
3.6	10.71	10.96	11.21	11.46	11.71	11.96	12.21	12.46	12.71	12.96	13.21	13.46
3.7	10.83	11.08	11.33	11.58	11.83	12.08	12.33	12.58	12.83	13.08	13.30	13.58
3.8	10.95	11.20	11.45	11.70	11.95	12.20	12.45	12.70	12.95	13.20	13.45	13.70
3.9	11.07	11.32	11.57	11.82	12.07	12.32	12.57	12.82	13.07	13.32	13.57	13.82
4.0	11.19	11.44	11.69	11.94	12.19	12.44	12.69	12.94	13.19	13.44	13.69	13.94
4.1	11.31	11.56	11.71	12.06	12.31	12.56	12.71	13.06	13.31	13.56	13.81	14.06
4.2	11.43	11.68	11.93	12.18	12.43	12.68	12.93	13.18	13.43	13.68	13.93	14.18
4.3	11.55	11.80	12.05	12.30	12.55	12 80	13.05	13.30	13.55	13.80	14.05	14.30
4.4	11.67	11.92	12.17	12.42	12.67	12.92	13.17	13.42	13.67	13.92	14.17	14.42
4.5	11.79	12.04	12.29	12.54	12.79	13.04	13.29	13.54	13.79	14.04	14.29	14.54
4.6	11.91	12.16	12.41	12.66	12.91	13.16	13.41	13.66	13.91	14.16	14.41	14.66
4.7	12.03	12.28	12.53	12.78	13.03	13.28	13.53	13.78	14.03	14.28	14.53	14.78
4.8	12.15	12.40	12.65	12.90	13.15	13.40	13.65	13.90	14.15	14.40	14.65	14.90
4.9	12.27	12.52	12.77	13.02	14.27	13.52	13.77	14.02	14.27	14.52	14.77	15.02
5.0	12.39	12.64	12.89	13.14	14 39	14.64	14.89	14.14	14.39	14.64	14.89	15.14
5.1	12.52	12.77	13.02	13.27	14.52	14.77	14.02	14.27	14.51	14.77	15.02	15.02
5.2	12.64	12.89	13.14	13.39	13.64	13.89	14.14	14.39	14.64	14.89	15.14	15.39
5.3	12.76	13.01	13.26	13.51	13.76	14.01	14.26	14.51	14.76	15.01	15.26	15.51
5.4	12.88	13.13	13.38	13.63	13.88	14.13	14.38	14.63	14.88	15.13	15.38	15.63
5.5	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75
5.6	13.12	13.37	13.62	13.87	14.12	14.37	14.62	14.87	15.12	15.37	15.62	15.87
5.7	13.24	13.49	13.74	13.99	14.24	14.49	14.74	14.99	15.24	15.49	15.74	15.99
5.8	13.36	13.61	13.86	14.11	14.36	14.61	14.86	15.11	15.36	15.61	15.86	16.11
5.9	13.48	13.73	13.98	14.23	14.48	14.73	14.98	15.23	15.48	15.73	15.98	16.23
6.0	13 60	13.85	14.10	14.35	14.60	14.85	15.10	15.35	15.60	15.85	16.10	16.35
6.1	13.72	13.97	14.22	14.47	14.72	14.97	15.22	15.47	15.72	15.97	16.22	16.47
6.2	13.84	14.09	14.34	14.59	14.84	15.09	15.34	15.59	15.84	16.09	16.34	16.59
6.3	13.96	14.21	14.46	14.71	14.96	15.21	15.46	15.71	15.96	16.21	16.46	16.71
6.4	14.08	14.33	14.58	14.83	15.08	15.33	15.58	15.83	16.08	16.33	16.58	16.83
6.5	14.20	14.45	14.70	14.95	15.20	15.45	15.70	15.95	16.20	16.45	16.70	16.95
6.6	14.32	14.57	14.82	15 07	15.32	15.57	15.82	16.07	16.32	16.57	16.82	17 07
6.7	14.44	14.69	14.94	15.19	15.44	15.69	15.94	16.19	16.44	16.69	16.94	17.19
6.8	14.56	14.81	15.06	15.31	15.56	15.81	16.06	16.31	16.56	16.81	17.06	17.31
6.9	14.68	14.93	15.18	15.43	15.68	15.93	16.18	16.43	16.68	16.93	17.18	17.43
7.0	14.80	15.05	15.30	15.55	15.80	16.05	16.30	16.55	16.70	17.05	17.30	17.55



APPROXIMATE ACREAGE IN PEACHES IN PENNSYLVANIA IN 1896, SHOWING ALSO THE LOCATION OF THE THREE "PEACH BELTS."

THE PEACH INDUSTRY IN PENNSYLVANIA.

BY GEORGE C. BUTZ

The modern industry of peach growing in Pennsylvania is but twenty-five years old, and though discouragements strike localities and individuals, yet the planting of orchards is increasing and new regions are found to be favorable to the production of fine peaches. After a number of visits to the peach-growing districts and with reports obtained from several correspondents in each county of the State, I estimate the total area in peach orchards in Pennsylvania at 11,000 acres, or nearly 2,000,000 trees all told. The largest portion of these is concentrated in but three or four counties, which contain the now well-known "peach belts" of Pennsylvania. The largest of these is

THE JUNIATA PEACH BELT

located principally in Juniata county, but extending prominently into Mifflin, Perry and Snyder counties. Careful estimates accredit to Juniata county 3,000 acres in peaches; to Mifflin county, 150 acres; to Perry county, 150 acres; and to Snyder county, 200 acres, making a total of 3,500 acres in this belt. The orchards are located upon the hills adjoining Shade Mountain and Tuscarora Mountain which mark the northwestern and southeastern borders of Juniata county. The next largest peach district is

THE SOUTH MOUNTAIN PEACH BELT

lying wholly within Franklin county, in Pennsylvania, but extending across Maryland to the Potomac river. There are about 2,500 acres in peaches in Franklin county, and, with the exception of a few scattered orchards in the lowlands of the county, the peaches are concentrated upon a comparatively small portion of the county, distinctly known as the South Mountain Belt. I cannot do better than quote the following description by D. Z. Shook, of Greencastle, Pa.: "The peach-growing belt as far as developed has an average breadth of three or four miles and, beginning at the village of Scotland, in Franklin county, extends southwestward, taking in the whole western slope of the South Mountain, about 20 miles in length, to the Maryland line. There are now in cultivation within

its total area not less than 400,000 peach trees. There are some fine orchards in spots all along the western slope of this mountain as far north as Dillsburg, in York county; and in the vicinity of Shippensburg peaches are succeeding so well that many thousands of trees are being planted yearly. There is but little doubt that the day is not far distant when the whole of this mountain slope will be devoted to the culture of peaches or other fruit, embracing a territory from the Maryland line to Dillsburg, and thence to the Susquehanna river, a distance of sixty miles." This belt produces finer peaches than the Juniata belt, and, if we lose sight of the Pennsylvania boundary line, it is of greater prominence as a peach district, for the belt extends into Maryland and widens greatly, so that there is double the acreage in peaches on the Maryland end of the belt, and the entire district contains probably in the neighborhood of 2,000,000 trees. This section is mentioned second only because it contains fewer trees in Pennsylvania than does the Juniata belt.

A THIRD DISTRICT.

This is made up of orchards not congregated in a belt, but scattered over the line of counties from York to Northampton. These five counties—York, Lancaster, Berks, Lehigh and Northampton—contain, as near as I can learn, about 2,300 acres, without any special concentration of the industry at any one point. In the counties on either side of this line reports indicate considerable attention to and profit in peaches. Dauphin and Lebanon counties, each with 50 acres; Schuylkill, 300 acres; Monroe, 100 acres; Berks, 500 acres; Montgomery and Chester, each with 200 acres.

Other counties are evidently making experiments with peaches. I find young peach orchards in the southeastern ends of Centre, Clinton and Lycoming counties and somewhat in the southern ends of Northumberland and Columbia counties. In the western counties the planting of peaches has been limited and spasmodic.

THE SIZE OF THE ORCHARDS.

In localities where the success of peach growing is not assured by experience, young orchards range from 500 to 1,000 trees. If a smaller number than 300 is planted, it is not likely to prove much of an experiment in determining the adaptability of a location to peaches because the probability is the trees will suffer more from neglect than attention. In a region where success is assured if proper cultivation is understood and given, there are orchards of six, eight and ten thousand trees each. At least one orchard of

10,000 trees is to be found in Pennsylvania, located in Franklin county.

SUCCESS AND FAILURE.

In every region in which peach growers and peach orchards were visited, two facts were strongly impressed upon the writer: First, that there are many farmers who have not found any crop in their experience in recent years that could yield them so large a profit as peaches, and their orchards received their best care and were a delight to the eye. Second, that there are also many farmers who have never had a dollar returned for their investment in peach trees and labor of planting them; their orchards are grown up with weeds and grass, dead and half dead trees predominate, the principal crop from the land is of weed seeds, peach yellows and borers. It is the universal opinion of successful peach growers that the price of their success was "eternal vigilance." They are frequent and thorough in the search for borers. They are convinced that tilling the soil during the entire life of the orchard is the best fertilizer. They exterminate diseased trees before the contagion spreads. They thin the fruit of overloaded trees that every peach may be perfect. These two kinds of farmers are often neighbors, with their orchards in view of each other, so that a difference in soil or atmospheric conditions cannot be claimed as the cause for the great difference in results. A farmer contemplating the planting of peaches should carefully study cases of failure as well as he does the cases of success and be thoroughly forewarned of the danger which lies before him and thereby be forearmed against it. There is yet too much of the careless practice of planting trees and then awaiting the luscious crop. As well might we plant corn, neglect its cultivation and expect a crop of ears.

PROFITS.

There is considerable uncertainty or variability in the quantity of a crop of peaches as well as in the price that can be obtained for them. This uncertainty and the utter failures in cultivation will tend to preserve the markets for the wide-awake and venturesome who can face the discouragements of an off-year. One extensive grower said if he "could be assured of 50 cents per crate for all the first class peaches he could grow, delivered at the shipping station, he would plant all his available land in peaches." If great care is exercised in marketing peaches, they will seldom net less than 50 cents per crate—$1.00 per crate is the most frequent price

which the grower receives. With a good crop, bearing trees will average one crate per tree, and it is an easy matter then to secure returns of from $75 to $150 per acre from peaches. In another year, however, the fruit buds may have been winter-killed, or for some other reason a very small crop follows, but the necessary labor of cultivation continues. These statements are made particularly for the farmer who is casting about for something to plant in his land which is yielding him but scant returns over his living while planted in the ordinary farm crops. It might be well for him to study the conditions of soil and location at his command with reference to peaches and determine if he cannot see the profit which so many other farmers have reaped. Each planter must practically venture as did the pioneers in the Juniata or South Mountain belts when they set out their first peach trees on the chestnut hills of Juniata and Franklin counties, ridiculed by their neighbors until the first good crop four years later brought them peaches and prices large enough to taunt the neighbors and cover all the expenses of planting and cultivation.

MICHIGAN PEACH ORCHARD EIGHT YEARS OLD, WITH VASE-FORM TREES. (Batley.)

SELECTION OF SOIL AND LOCATION.

The one great hindrance to peach growing in Pennsylvania which cannot be overcome by human efforts is what is known as the *winter-killing* of the fruit buds, and with it may be included the destructive frosts that sometimes occur at the time of blossoming. The

A SLOPE FOR PEACHES IN SNYDER COUNTY, PA

degree of temperature of the winter season is not the only condition which causes the destruction of peach buds, for certainly the peach trees standing on the bare hilltops and exposed slopes of the mountains in Juniata and Franklin counties suffer a lower temperature during the bleak winter than trees in sheltered spots, and yet trees in the valleys suffer more from winter-killing of fruit buds than do those on the hilltops. If the wood and buds are properly matured in the fall before the checking cold snaps occur, the tissues are prepared for all the severity of our climate, and Prof. Bailey has pointed out that a decided drought preceding the winter may be regarded as a direct cause for the winter-killing of vegetation generally. In any region of the State peach growers have sustained a more or less complete failure of fruit by winter-killing at least once in four years.

In Snyder county I ascended to a peach orchard on the very top of a hill which rose probably 300 feet above the surrounding valley. It was three miles from the owner's home and after driving to the foot of the hill the ascent was too steep to be driven, so we climbed up afoot. The orchard was in a fine growing condition and promises its first crop in 1897, by which time the proprietor expects to have graded an easy incline for travel. The hill is exposed to winds from all sides and yet such locations have been found to be very desirable for peaches. This orchard is moreover six miles from the nearest railroad shipping station, and yet in this respect it represents a fair specimen of the location of peach orchards in the mountainous portions of the State, some of them being twelve miles from the nearest railroad station, necessitating the hauling of the fruit that distance in wagons. Nevertheless the desirability of locating a peach orchard near a shipping point must not be lost sight of or underrated. A very frequent complaint is of the expense of getting the peaches to the markets, for the freight charges are always deducted before the shipper receives his returns.

The soil which is best suited to the peach is that formed by disintegrated sandstone or shale. In some thrifty orchards the disintegration is so imperfect that a heavy rain following plowing would wash the loose soil under the stones and the field looks as if mulched with stones varying in size from that of walnuts to that of a volume of the Congressional Record. The red shale lands of Juniata county are prominently the peach lands in that belt, and many of these were formerly regarded as too poor for farming. The gray or olive shales have been utilized in other counties with great satisfaction. In Franklin county the favorite peach soil is a very loose sandstone, sometimes mingled with considerable flint and gravel; soil on which the chestnut abounds. In fact, a good

criterion to regard in selecting a peach soil is the presence of the chestnut. Many orchards are planted in clayey loams, but do not thrive so well nor yield as fine fruit as do those on slaty, sandy or gravelly loams. There are such soils in many localities of the State where the growing of peaches has not yet been thoroughly or properly tried.

Some peach growers in the Juniata belt, seeing neglected slopes of that region not owned by themselves and not wishing to purchase the land, have entered into agreements with the proprietors to prepare the ground for peaches, furnish and plant the trees and attend to all the care and cultivation necessary until the first fruit is ready to pick wholly at the planter's expense and afterwards the expense and profits to be divided equally between the farmer and the landlord.

THE PLANTING OF PEACH ORCHARDS.

The ground for peaches is usually prepared as carefully as for corn, by plowing and harrowing when the ground is in a fit condition in the spring to insure thorough pulverization and is then cross marked to locate the positions of trees. In a strong soil where it is expected the trees will stand fifteen or more years, the distance between trees should be 20 feet x 20 feet, but in the majority of the Pennsylvania orchards the distance is 16 feet x 16 feet, because it is found that 12 years is the limit of the profitable life of an orchard, and by a system of pruning the heads of the trees are kept from interfering; 16 feet x 20 feet and 18 feet x 20 feet are distances sometimes preferred. The holes should all be dug before the trees are received, so that the planting may be done as expeditiously as possible.

Before planting the trees they are all pruned, cutting away every side branch, leaving only the cane-like trunk which is shortened to two or two and one-half feet and all bruised parts and ends of roots are cut away. The trees are then planted and the ground is firmed about the roots by tramping with the feet; the winds then have little opportunity to move the trees from their places. No further pruning is done until the trees are four years old, except on occasional trees which do not grow symmetrically. The trees should be set just enough deeper than they had been in the nursery so that when the ground is fully settled they will stand at the same depth. It is customary among the best orchardists to follow up a young orchard for three successive years and replace with new trees all the misses that might occur from whatever cause.

A further word of instruction in the planting of a peach tree might not be out of place in this connection. Often the inclination to be very kind to a young tree induces the inexperienced planter

to put some manure directly to the roots of the tree, or to throw mud on the roots. Such practices are wrong and unnecessary. The ground at time of planting should not be so wet as to make mud, nor so dry that it will not adhere when pressed into a ball, and the proper conditions usually exist in spring. Then no manure or water are necesary at time of planting. If, however, the roots of the trees on arrival are very dry, they should be soaked for a few hours in water, and if there seems to be a dry spell prevailing the roots might be dipped into a mud of clay and water to put a coating over the roots and prevent further evaporation. All straw, weeds, stones or very dry earth should be kept out of the hole when planting, and the ground must be made firm about the roots to exclude all air or chances of rapid drying. Any loose material may be used to mulch the trees if a drought should follow planting.

ORDERING TREES.

Some peach men who are more or less extensively in the business grow their own trees and also for their neighbors, but the majority of them, as should beginners, purchase their trees from the nurseries. In such cases it is well to stipulate in a contract for trees certain requirements by which inferior trees may be rejected. The trunks should be smooth, the roots not badly injured, the top preferably on peach roots (except when to be planted in heavy clay soils, then they might be on plum roots). Recently much is said of June-budded trees versus August-budded trees, but the former possess no advantage over the latter except in that the budded top is formed one year earlier upon the seedling peach, and this advantage can serve only the man who grows them. Trees ordered from the nursery are always August-budded stock. It is well to require some guarantee that the trees are free from fungi and injurious insects, particularly the much-dreaded San Jose scale.

When received each tree should be carefully examined for any indication of root gall, root knot or black aphis upon the roots, borers at the crown and the San Jose scale upon the trunk and branches, and if any are discovered the trees should be treated as indicated under the proper subject in the latter part of this bulletin.

PEACH ORCHARD WITH LONG TRUNKS AND ROUND-HEAD TRAINING, MICHIGAN.
(Bailey.)

SUCCESSFUL VARIETIES IN PENNSYLVANIA.

It is difficult to make a selection of varieties of peaches for any locality that will not include a certain number which will sooner or later be discarded because of their unprofitableness. There is variation not only in the size, color and quality of the fruit, but also in the liability to winter-killing, the time of blossoming, the tendency to mildew and rotting of fruit and the productiveness of the trees, and the exact behavior of a variety cannot be determined for a particular region until tried, so that the best experience which should guide in making a selection of peaches is that of one's nearest neighbor when it is to be had. D. Z. Shook, of Franklin county, writes in the Report of Department of Agriculture of Pennsylvania: "The experience of the past has convinced the growers of this (the South Mountain) belt that late varieties will not only thrive best, but that they also afford the greatest monetary returns. This statement applies particularly to the trees planted upon the more elevated portions of the belt. Amongst the most profitable varieties may be mentioned the White Heath Cling, Salway, White Heath Freestone, Bilyeu's October, Levy's Late and others. These ripen in the South Mountains in their varying succession from September 25th to October 17th. While the most elevated land is best adapted for raising late varieties, it has been learned that the following named varieties will do well and prove satisfactory on both high and low land: Crawford's Early, Crawford's Late, Mountain Rose, Reeve's Favorite, Moore's Favorite, Old Mixon Free, Stump of the World, Chair's Choice, McAllister, Wonderful, Beers' Smock,

Fox Seedling and others. The above-named varieties include both early and late, and all of these have been found profitable in this section."

There have been grown in this section with moderate success other varieties which have gained reputations elsewhere, such as Elberta, the favorite of the Southern states. It is reported in this region to lack in quality while it is a good yielder. The Crosby, a favorite in Connecticut, is not making a good record among the older varieties of this region. Susquehanna is a Pennsylvania variety originating with Mr. Griffith, along the Susquehanna. It is a large, yellow, red-cheeked peach of fine quality, ripe the last of August, but because the trees are not prolific bearers, this superb peach is not often planted for market. Ward's Late Globe, Steven's Rare Ripe, and Wager are other varieties tried with only moderate satisfaction.

In Juniata county these same varieties have been growing, but the recommendations center now upon Mountain Rose, Old Mixon, Stump, Crawford's Late, and Smock for extensive planting. Salway, formerly much planted here, is losing favor because of its tendency to crack and rot. In Lancaster county the principal varieties recommended are Mountain Rose, Old Mixon, Stump, Reeves, Late Crawford and Smock.

In Lehigh county the varieties run: Mountain Rose, Stump, Wonderful and Elberta.

In Bucks county, W. H. Moon writes the list of the most satisfactory varieties as follows: Newark Seedling, XX Yellow, Pride of Franklin, Mountain Rose, Globe, Crawford's Late, Beer's Favorite, Susquehanna and Old Mixon.

In selecting peaches for a commercial orchard it is well to bear in mind that the market prefers yellow-fleshed peaches to white-fleshed peaches, even though the latter are as a class of a better quality. Mountain Rose, Old Mixon, Stump and Bilyeu's October are all white, but are largely planted because of their productiveness. The Crawfords, Foster, Elberta, Reeve's and Salway are yellow and firm. A clingstone should be avoided as one would avoid an enemy. All the above varieties are freestone. The only clingstone that I have found in the Pennsylvania orchards is Alexander, planted because it is the first to ripen.

In planting an orchard without previous experience the list of varieties should be short, made up of the old and well-tried varieties, selected to ripen in a succession that no two varieties will be thrown upon the market at the same time.

CULTIVATION.

The peach orchards in the finest condition are as a rule those which have been systematically cultivated and fertilized. And the

peach growers who talked of going out of the business or who were disappointed in their results were those whose orchards were grown up in weeds and grass, or whose trees were suffering from borers and other evidences of neglect. The practice in this whole matter differs greatly in this State, some orchardists planting no other crop in the ground planted to peaches, while others habitually plant corn for the first two or three years. Frequently they sow a grain or grass which prevents all opportunity of cultivation and therefore is an erroneous practice. The first principle to be observed in the cultivation of the peach is to *keep the ground stirred every year from May to July inclusive.* The orchard should be torn up in the spring as soon as the weeds start by shallow plowing and this treatment be followed by frequently going over with a good harrow or cultivator. It is not yet a general practice to put in some crop to cover the ground in the winter and to be plowed under the following spring, but many planters have tried it and believe the practice to be a very important treatment in the proper care of soils in orchards of any kind.

There is no serious objection to the cultivation of a peach orchard during the first two years with a crop of corn, cabbage, tomatoes, melons or strawberries, but serious detriment to the peaches will follow the planting of any grain crop, grass or potatoes. It often happens that it is not desirable or necessary to plant catch crops among peaches; where this prevails the stirring of the soil over the whole surface should not be less frequent. On the other hand, there are soils too rich for the peach and which cause a wonderful growth in the young peach tree, making branches of a season 8 to 10 feet long with numerous and stout side shoots, arousing in the heart of the owner a pride similar to that possessed by the mother of the child "rolling in fat;" both tree and child are weakened by their overfed condition and are easy prey to disease and disaster. Peaches in rich soils therefore would be benefited by sharing with other crops for the first two or three years.

FERTILIZERS.

I would place before every person setting out peaches a quartette of words which will form a key to success in peach growing and by the proper use of which he might exclude failure in the production of peaches. These words are *Cultivate, Fertilize, Borers, Thin fruit.* They indicate operations which must never be lost sight of and their importance is usually not impressed upon one's mind until it has been taught by a sad experience. The first of these has been spoken of; the second now claims attention.

WITH AND WITHOUT FERTILIZERS.

Rich soils will require no other fertilizer than that which would be properly given to the catch crop planted with the peaches for the first two or three years. When the trees come into bearing they should receive annually an application of fertilizer containing potash and phosphoric acid, with little or no nitrogen, because the two first named ingredients are fruit formers, and the last named is a plant former. On poor soils, such as are usually chosen for peaches, the fertilization could profitably begin in the first year by the use of a nitrogenous fertilizer. On this point Dr. E. F. Smith, who made many experiments with fertilizers in connection with his study of the peach yellows, writes as follows: "There can be no objection to

the use of well-composted barnyard manure. Where this is not procurable, dependence must be put upon clover and commercial fertilizers, taking care always that the latter are obtained from reliable sources. In general, the dependence should be put on potash salts and phosphates rather than on nitrogenous fertilizers. The peach can be injured readily by excess of nitrogen. Its effect upon the trees is to produce an excessive growth of wood and foliage at the expense of the fruit. Fifty to a hundred pounds per acre of nitrate of soda, or its equivalent in dried blood or sulphate of ammonia is usually as much nitrogenous fertilizer as any orchard requires and many orchards do not need at all. Muriate of potash, kainit, sulphate of potash may be used in large quantities without injury. Four to five hundred pounds per acre will do no harm, provided it is not put too close to the trunks of the trees. The same remarks apply to dissolved rock phosphates and to bone superphosphates and various bone mixtures. They have been applied in large quantities, even as high as a thousand pounds per acre."

If the practice of fertilizing peach orchards in Pennsylvania is considered as the experience of the majority of peach growers, it must be said there is no practice, for the great bulk of trees are entirely neglected in this regard; but if the experience of men who have made a study and success of growing peaches is considered, then it may be said that applying fertilizers is a regular practice, varying according to the needs of the soil and trees. The poorest soils are fertilized moderately each year; good soils are treated strongly every other year, and the rich soils once in three years. Men who undertook to fertilize their orchards after a few years' experience of total neglect were surprised at the remarkably beneficial effect upon the trees and the crop of fruit. In all my visits I found no grower who had tried fertilizers and discontinued the use from a lack of faith in their utility.

The potash salts and phosphates are scattered over the ground in the fall and plowed under whenever it is possible, and fertilizers to supply nitrogen are applied in the spring.

There should be considerable advantage in the use of fertilizers containing insoluble phosphates by those orchardists who apply fertilizers but once in two or three years and particularly in the loamy and clay soils. In a series of experiments carried on at this station to determine the relative merits of the soluble, reverted and insoluble forms of phosphoric acid, the results showed that in a term of years the lasting effect of the insoluble phosphates was greatest, though all were valuable inversely as their solubility. It is well to remember when applying fertilizers that it is posible to render available for the trees some of the nitrogen of the atmosphere by

the growing of legumes as catch crops among the trees. Crimson clover and cow peas have been repeatedly used with satisfaction. By sowing the seed in July and plowing the crop under in April, the soil has a natural covering during the period when no cultivation is necessary.

FOUR YEAR OLD ORCHARD, FORKED LOW

PRUNING.

Practice varies greatly in the matter of pruning all the way from a severe annual "shortening in" of the season's growth to no pruning at all, according to the notion of the orchardist. The considerations to be regarded at the outset are: First, at what height shall the trees be forked? This is regulated at the time of planting the trees by heading back the cane to one, two or three feet above ground, according as a low, medium or high head is desired. Practically, the high head permits closer working under the trees with horse and cultivator, while the low head renders picking and thinning the fruit easier. The high top exposes the trunk greatly to the sun and usually forms a dense head, while a low top is usually spreading and loose, which insures a better coloring and ripening of the fruit. The low spreading head will yield the finest fruit, other things being equal, and will require no pruning except such

EIGHT YEAR OLD ORCHARD, FORKED LOW, SPREADING HEAD.

as an individual tree should receive to maintain its balance and symmetry and to conform it to the open vase form of top. Trees forked at two and a half or three feet are by some orchardists pruned to keep the heads and fruit low by cutting off two to four feet of all strong growths of the previous season, the pruning being done in early spring, involving no little labor. Fortunately the peach will stand considerable pruning without injury, and it is worth considering at all times just how much can be done with profit. On rich soils which stimulate excessive production of wood more pruning can be profitably done than on poor or typical peach soils, but never should the small laterals which bear the fruit buds be cut away until they are dead.

THINNING.

This is the third very important operation in peach culture which is greatly neglected in Pennsylvania and all over the United States as well, and yet no peach grower has failed to see the difference in the fruit of a tree yielding a moderate crop and that of one overladen with fruit. By thinning the fruit on a tree that promises an excessive crop the following advantages are gained:

The tree may form fruit buds for a good crop the following year.

The limbs will not require propping nor break under a storm.

The fruit will be large, highly colored and finely flavored and command the best prices in the market.

This work is performed early in July, or, more properly expressed, just after the "June drop." The peaches are then about the size of hickory nuts and all that remains on the trees after the June drop are likely to be carried to maturity. If they hang thickly on the trees, careful workmen are sent into the orchard with step-ladders and by means of the thumb break out all superfluous fruits, so that the remaining fruits will stand about four inches apart. The past season was a favorable one for observing the effects of thinning. Several large orchards visited in July had been thinned and the ground under the trees was strewn with shriveled peaches, and often there were more on the ground than on the tree above it. Later reports from these orchards indicated the most gratifying results from this practice of thinning, both as to quality of the fruit and the profit derived from the crop.

Thinning is beneficial not only to the immediate crop of fruit, but also in preserving the health and vigor of the tree. It is well known that if a tree has borne a tremendous crop, little can be expected of it the following year. The peach grower will make the finest profits when his neighbors have no fruit and by providing for the future while carefully caring for the present day, he is likely to command such a condition of things. The regular thinning of peaches is more of a general practice in California than it is in the East, and it would profit the eastern fruit grower if he would study the methods of his western brethren.

PICKING AND MARKETING.

It is in this part of the peach business that the greatest care and most constant alertness must be exercised by the grower to reap the reward of his labors. He should have acquaintance with the markets at several points before his peaches are ripe. Outside of the two great peach districts in this State, the peaches are practically all sold in the county where they are grown or in the nearest large city. Franklin and Juniata counties ship principally to the dealers in the large cities of this and the neighboring states. In the past two years more distant western cities, even as far as Chicago, were supplied with peaches from the South Mountain belt shipped in refrigerator cars. By having access to several markets, the disastrous gluts or "slumps" may be avoided. It is a good practice to visit the markets occasionally that one may see his own fruit displayed with others and that he may become personally acquainted with his dealer in whom he places great confidence.

PEACH CRATES.—1 California; 2 Florida, 2' Single basket from same; 3 Michigan; 4 Delaware; 5 North Carolina.
(E. F. Smith, Farmers Bulletin 33, U. S. Dept. Agr.)

The fruit is commonly packed in the Delaware peach basket, called the one-half bushel basket, holding $\frac{5}{8}$ bushel, and the peach crate, sometimes called the Pennsylvania crate, having a capacity of $\frac{1}{8}$ bushel, divided into two sections. The basket is used by some growers exclusively, and until very recently it was the only carrier in the South Mountain region. In the Juniata region the use of the crate has been general for many years. The baskets are used for local markets or for shipping the finer quality of peaches, and the crates are preferred for large shipments, because they pack into cars to better advantage. The growers are beginning to realize that peaches must be put up in the most convenient and attractive packages to suit the purchaser to insure ready sale, and therefore the Florida crate, constructed to hold six baskets, without handles, each having a capacity of about 10 lbs. of peaches, were used to ship the best quality of peaches to such points as New York, Philadelphia, Baltimore and Washington. Another form of package just coming into use in this State is the Michigan basket, having a handle and a raised lid and a capacity of 20 pounds of peaches. The use of these smaller packages will bring greater profits. Many a small basket of peaches would be carried home in an evening by purchasers as is now done with grapes because they are attractively packed and convenient to handle. I have often seen peaches refused because the dealer would not break a crate and the purchaser wanted only a peck or half peck for a small family. There are more small families than large ones.

Too many peach growers do not grade their peaches and therefore their city dealer grades them as having only inferior fruit to be sold accordingly. It is in grading the fruit that the shipper makes and preserves his reputation and by this means he receives the phenomenal large prices while his careless neighbor complains of low prices. The fruit should all be in the same stage of ripeness carefully laid in the basket so that there will be no settling during handling, and no imperfect fruit should be put in the first grade lot. All inferior fruit should be kept at home and whatever cannot be used at the evaporator should be fed to hogs.

There is a proper time for the picking of peaches, which can be determined only by experience. The fruit on a given tree does not all ripen upon the same day and therefore cannot be picked at one time. Three or four pickings over the same variety must be made to put the fruit upon the market in the best condition, and thus green fruit and over-ripe fruit is avoided. If the fruit has been properly thinned after the June drop, there is but little work of selection necessary, but if this important operation was neglected, there will be an abundance of second class fruit. The fruit is usually picked in the half bushel peach baskets and too often receives no further attention than to be covered and shipped. They should then be assorted in the orchard or after hauling to the packing house or shed and handled from one basket to another as if they were eggs. This work cannot well be entrusted to hired labor, but must be reserved by the grower, who should be able to testify to the quality of every peach in the crates bearing his name.

The hauling of peaches should be done upon wagons with springs, and the greatest haste compatable with the necessary care should be exercised to put the fruit on its way to market. Many large peach growers have their orchards twelve or fifteen miles from the nearest shipping station, with the ordinary country roads, which, however, are likely to be at their best in the peach season. The expense of hauling a large number of crates ranges from one to two cents per crate.

Fruit which has become too ripe for shipping at the time it is picked or such as has a blemish is evaporated at home. "In the South Mountain belt there are three canneries," writes Mr. Shook, "with a combined capacity of forty thousand cans daily, that are in constant operation during the peach season. One of these is at Waynesboro; the other two are at Rouzersville." Good fruit which does not find a more profitable market is sent to these canneries, to be canned or evaporated.

PEACH TREE WITH FIRST SYMPTOMS OF YELLOWS.
This magnificent tree bearing its first crop ripened the characteristic premature fruit. It is promptly destroyed by the axe and fire.

THE ENEMIES TO PEACH CULTURE.

There are some peach growers who would say there are no enemies to peach culture (except perhaps the railroad companies) for even the prevailing and destructive "yellows" and the troublesome borer he regards as friends because they discourage his neighbors from competing with him for the profits of the business. These men do not hesitate an hour to yield up any tree which the "yellows" might claim, and continue no dispute with that enemy. One might think such men worshiped the borer, seeing they are often on their knees before the insidious foe.

Yellows.—Having submitted to peach growers in various sections of the State this question: "What percentage of trees are destroyed by yellows in ten years' time from planting?", the answers were remarkably different.

From Juniata County—"More die from neglect than from the yellows."

PEACH YELLOWS IN THE FOURTH YEAR.
(E. F. Smith, Farmers Bulletin 33, U. S. Dept. Agr.)

From Huntingdon County—"The borer kills them before they are eight years old. When they appear to die of yellows the borer is at the root."

From Dauphin County—"Sometimes all are destroyed, depending on the health of original stock and the care given the trees."

From Lancaster County—"More than fifty per cent."

From Mifflin County—"About fifty per cent."

From Snyder County—"Fully seventy per cent."

From Union County—"One hundred per cent. in my experience."

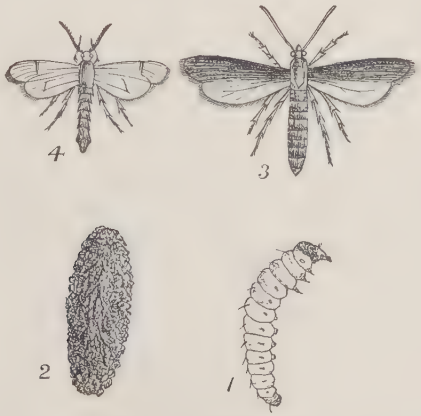
From Franklin County—"Over fifty per cent."

From Bucks County—"The yellows have injured but few trees here."

These replies indicate that while there is considerable destruction due to yellows, there is also much that is due to neglect of borers and other damaging influences. In the sections quoted the peach has been grown for over twenty years, and the result of their experience shows the average life of an orchard to be ten years and that from fifty to one hundred per cent. of the trees are in this time destroyed by the yellows, a giant destroyer; yet in the face of this the courageous orchardists continue to plant peaches, and profitably. The disease is a mysterious one, its cause never having been satisfactorily determined. Much has been written upon the

subject and every peach grower should learn to know and familiarize himself with the true symptoms of the disease. It is contagious, attacking all varieties of peaches at any time in the life of a tree, particularly when in flower. It is hereditary, therefore pits or buds should not be taken from a diseased tree for stocks or budding. There is no remedy for the disease. The practice in regard to it is as follows: Every tree showing the first signs of the disease is marked by blazing the trunk so that the following winter it may be readily found, when it is cut down with the ax and burned. Trees apparently in their prime of life, bearing their first or second crop, with a full symmetrical head of strong wood and large dark green leaves are blazed because the fruit ripened prematurely and showed the characteristic purple spots. Too often, however, such trees are allowed to stand and spread the contagion, and the diseased fruit goes to market. This brief reference cannot convey all that should be known about the yellows and the purpose here is simply to emphasize the annual burning of all trees showing the slightest symptoms to save the healthy trees from attack. Not every orchard suffers so severely as to be totally destroyed in ten years. I saw one orchard of four thousand trees which has stood fourteen years with but ten per cent. of trees missing.

Borers.—This is the great insect enemy of the peach, the one insect that is in every orchard of the State, doing great harm. The practice of the careful orchardist and that which can be recommended is to visit every tree twice each year—spring and fall—and carefully remove the ground from the base of the trunk, then if any sawdust like casting or exudation of gum or hole through the bark is discovered, the offending borer is dug out with a knife. It is a tedious work and must be entrusted to only careful workmen,



PEACH TREE BORER.

1. Larva or worm; 2. Cocoon; 3. Female; 4. Male.
E. F. Smith, Farmers Bulletin 33, U. S. Dept. Agr.)

otherwise much damage might be done to the trees by unreasonably cutting the bark. Various washes and protecting bands are recommended, but if tried must not be wholly depended upon, for they often fail for one or another reason. The borer is the larva of a pretty moth which lays its eggs on the bark, usually at the base of the trunk in June, July or August. After hatching the larvae eat through the bark to the sapwood, causing the gummy exudation. They then bore through the soft tissues at the base of the trunk and in the larger roots, eating as they go, for about one year, except during the winter months of inaction. They are then full grown and emerge to construct cocoons, which are made of their silks and castings with the gummy exudation from the tree. In these cocoons they change to pupae and three or four weeks later change to the day-flying moths, which lay the eggs. This is the one enemy of the peach which can be easily controlled, by a little

SEVERE WORK OF BORERS.
Destroying Fruit and Trees.

simple labor twice each year. It may attack a tree soon after it is planted and prevent its ever bearing fruit. It may attack the tree in the prime of its bearing age, when its profusion of blossoms promises a full crop of fruit and by the excessive work of the

larvae the tree may die in mid-summer before the fruit has matured. The frequent specimens of this were seen in my visits. The trees were leafless, loaded with fruit half developed and the loss of the fruit and death of the tree were both due to the neglect of ten minutes of labor in the early spring. Not every tree is attacked and occasionally an orchard may escape the borer entirely for several years, but such fortunate orchards should be inspected nevertheless once each year.

But little anxiety or care is displayed by the peach growers of Pennsylvania for any disease of a fungous nature other than the yellows or for any insect other than the borer, although the peach tree is subject to the attack of the following:

OTHER FUNGOUS DISEASES.

Fruit Rot.—The most serious of these diseases is the fruit rot, which is caused by the same fungus that effects twig blight (*Monilia fructigena*). The evidence of its existence in the orchard is in the mummified fruits that hang upon the trees through the winter and the presence of many dead twigs. The disease creates alarm when the young fruit begins to rot upon the trees. Many of such affected fruits drop but some dry up upon the tree and remain there until the following year, and from them the disease may spread more extensively in the succeeding crop and growth. Professor F. D. Chester, of the Delaware experiment station discovered that this fungus may destroy the flowers in spring and the injury be regarded as caused by frosts. His experiments with fungicides have showed that the injury caused by this fungus may be greatly reduced by the proper spraying with copper fungicides. In this treatment Professor Chester urges that all mummified fruits be gathered and burned. Then before the fruit buds begin to swell in spring spray the tree with a solution of one pound of copper sulphate in twenty-five gallons of water, and just before the fruit buds swell spray a second time, using Bordeaux mixture or copper carbonate, and a third spraying, using one of these solutions, should follow before the buds open. When the blossoms begin to fall spray with bordeaux mixture, to which has been added three ounces of Paris green per barrel of the mixture. Repeat this in ten days or two weeks As soon as the fruit shall have reached full size and begins to show signs of color, spray the tree again with copper acetate, using 4 ounces to 50 gallons of water. This should be followed by one or two more sprayings of the same solution at intervals of seven to ten days during the ripening period.

Black Spot.—This disease renders many of the peaches grown in Pennsylvania inferior both in appearance and taste; it is due to a fungus (*Cladosporium carpophilum*) which shows a preference for

certain varieties of peach, particularly the later ones. It is recognized by the sooty-black spots on the surface of the peach. These spots are usually clustered on one side of the fruit and the flesh is thinner and dryer under them than where they do not occur, and the cracking of the peach is caused by this fungus. The best remedy for this disease is Bordeaux mixture, although its use has not yet been satisfactory enough to become a practice.

Peach Mildew.—While the peach is very small it may be attacked by a fungus (*Podosphaera oxyacantha*) which appears on the surface of the peach in white frost-like or moldy patches; similar patches occur on the leaves of the tree. Later the patches become brown and hard and the fruit cracks.

Leaf Curl.—This disease attracts considerable attention in certain seasons and particular localities. It may be very generally present in orchards but excites no alarm until its attack is severe, causing the foliage to drop from the trees early in the season. The fungus (*Taphrina deformans*) causes a strange curling of the leaves soon after they appear in spring. The tissues swell and the surface turns yellowish or pinkish and within a few weeks the leaves drop and the fruit, if any hangs, fails to develop.

Against all these fungous diseases the copper fungicides have been used by a few experimenters with only moderate success, and unless the fruit grower is apt at experimenting for himself, he is not likely to undertake a remedy that will not assure a decided protection.

BRANCH OF PEACH—Showing perforation of the Pin-hole Borer. (Natural size.)
(E. F. Smith, Farmers Bulletin 33, U. S. Dept. Agr.)

OTHER INSECT ENEMIES.

Pin Hole Borer.—There is considerable evidence in the orchards of this State of the European beetle (*Scolytus rugulosus*) commonly called the pin hole borer or fruit barkbeetle. It has become troublesome in recent years in the Eastern States. The beetle is black and only a tenth of an inch long. It bores a clean round hole like that made by a large pin through the bark of the trunks or limbs of fruit trees. Fifty or a hundred such holes may occur on a trunk severely attacked. The plum, peach and apricot are most frequently attacked, but the cherry, pear, apple and quince are also likely to be infected. The insect seems to prefer sickly trees and then materially hastens its death or uselessness. There

PIN-HOLE BORER BEETLE—Magnified 20 diameters.
(E. F. Smith, Farmers Bulletin 33, U. S. Dept. Agr.)

is no remedy known but it is wise to burn up all dead wood of the orchard promptly and similarly dispose of trees badly infested by this beetle.

Curculio (*Conotrachelus Nenuphar*).—This insect is present in every orchard and in its own way destroys many peaches. It lays its eggs upon the young fruit, beginning as soon as the blossom has fallen. In consequence of the punctures made by the curculio many of the peaches drop; if the fruit hangs on the tree the eggs hatch and the peaches become "wormy." Spraying the curculio has not been a satisfactory remedy. The old-fashioned way of jarring the trees and catching the insects as they drop is the only method to be recommended to prevent serious results.

Black Peach Aphis (*Aphis Persicae-niger*).—An insect not yet much complained of in Pennsylvania and one that every planter should be on the lookout for when receiving his trees, is the black aphis, which does its worst work uponthe roots of the peach tree out of sight. Infested trees should be burned or dipped in an insecticid · before planting. When this aphis works upon the roots of a tree its foliage is yellow and the tree is thought to be diseased with the yellows.

San Jose Scale.—The San Jose scale *(Aspidiotus perniciosus)*, which is now established in the east, should alarm every fruit grower to such an extent that he would closely inspect every tree and shrub that comes upon his grounds in the fear of the introduction of this pest.

There is a disease of the peach which cannot be classed under either fungous or insect causes. It has been given various common names, as crown galls, root galls and root tumor. It occurs upon the roots of the peach and several other trees, and upon raspberries and roses. It forms large corky swellings upon the roots, principally near the crown, but may be upon smaller roots two feet from the crown. These knots or galls vary in size from that of a pea to a baseball, and are supposed to be caused by mechanical injury,

though it seems rather improbable. No insect, worm, fungus or germ has been found to be regularly associated with it, and the true

ROOT GALLS (Bailey).

cause is therefore a mystery. Trees affected by it turn yellow and cease growing and may be supposed to have the "yellows." They should be taken up and burned and until a satisfactory explanation is reached the disease should be regarded as contagious. It occurs among the young trees of the nurseries and should be looked out for when trees are received and rejected without a question.

Root-knots caused by nematodes or "eel worms" must not be mistaken for root-galls. In the root-knot, which is usually a small swelling on the root, may be found with the use of a microscope, the little worms in various stages.

CHESTNUT CULTURE FOR FRUIT.

BY WM. A. BUCKHOUT.

Many of our cultivated fruits have come to us from the old world where they have been under cultivation so long time that the place and circumstances of their origin are entirely unknown. Some others are derived from American species, and are so plainly related to the wild native fruits that their transformation under careful cultivation and selection can be very clearly traced step by step.

There are certain native fruits, however, which, until recently attracted very little attention as of possible value under cultivation. These are the various nuts, such as the chestnut, hickorynut and walnut. This is perhaps accounted for by the great ease with which the ordinary fleshy fruits are produced, their general profuse productiveness and the agreeable contrast in food supply which they present to the staple articles of diet. Moreover the spontaneous yield of the nut trees has seemed to be ample for all needs, and they have always appeared to be rather intractable subjects when brought under cultivation, and to require a good deal of time before coming into bearing. It is, however, necessary to take but a brief retrospect of fruit culture in general to see how completely ideas of its feasibility and profitableness have changed within the past twenty-five years.

Middle-aged men readily remember when there was no such thing as small fruit culture in the United States, except as people supplied their own tables from a few plants in their gardens. Small fruits were not raised to sell, for it was thought neither feasible nor profitable to do so.

With changed conditions of ease of transportation, systematic methods of culture, etc., a great industry has arisen, which involves thousands of men and a great capital to keep it in operation. From being a small business, carried on perhaps as a temporary make-shift, or in connection with other kinds, it has grown to be the chief occupation in many localities, and has even invaded districts long wedded to the production of certain staples only, and has materially changed their agriculture. In the diversification of industries which is now deservedly attracting so much thought and attention, the increase of our plants of cultivation should find a place, and of cultivated plants the nut-producing trees are among the most promising. The nut trees differ very much in certain particulars from other trees which produce edible fruits. They are of the first rank as to size, and the fruit is the true seed only, and is not made up of fleshy coverings of the seed as in the apple, peach, etc. Nuts have, therefore, much less water and a higher nutritive value generally. They are rather of the nature of staple articles of diet and approach the grains in food value. They are, moreover, not of the perishable class and are easily handled with little waste and risk. While all of the nut trees are probably capable of improvement, and each has adaptation to its particular situation, the one most promising in this latitude is the chestnut.

The chestnut is a native of the eastern United States, particularly the mountainous parts, where in the higher and drier soils it is one of the most common as it is one of the most useful of our trees. It is not as widespread as many others and is somewhat limited by soil conditions as well as by latitude. It is not a tree of wet or heavy soils, nor can it be grown successfully in them. Apparently it succeeds but poorly in limestone land, but whether from the lime which it contains or because of its heavy clayey character is not known. But in gravelly soils such as are common and extensive in hilly districts it grows luxuriantly, becomes well developed and productive. The localities in which it can be satisfactorily grown are hence quite readily determined. To some extent it can and has been grown in places where it is not native, and in soils not of light and gravelly nature, but generally imperfectly and with difficulty, and the trees have been sterile or at least irregular and uncertain in fruiting. It has been noticed that near the borders of the area in which this tree is native it is quite liable to be barren and to attain a meager size and development. To avoid disappointment one should satisfy himself that both climate and soil conditions are favorable before attempting chestnut culture.

The chestnut grows naturally from the seed or nut, and also reproduces itself indefinitely by sprouts from the base of the trunk.

Paragon Chestnut Tree 8 Years Old

This second method is very common, particularly in newly cleared land, and makes more easy and rapid the renewal of these trees than of those kinds which grow from the seed alone.

In growth from the seed it is found that the nuts lose their vitality in a remarkably short time, and hence special care must be taken either to plant them very soon after they are gathered or else to keep them so protected that their vitality is not impaired. Loss of vitality is practically coincident with loss of moisture, and nuts once dried will not germinate, while those partially dried will be more or less uncertain in their germinative powers. Nine-tenths of all failures in the germination of this and many other seeds usually comes from drying or the inability of the seed to procure sufficient moisture during germination. Nuts intended for planting should be kept buried in soil, or, better still, coarse saw dust or litter, slightly moist, until they can be planted. If possible nuts should be planted where the trees are to stand. The seedling is characterized by a remarkably long and vigorous tap root. It much exceeds the stem in both length and thickness. If allowed to grow without removal there is no check on growth; if transplanted it is impossible to avoid some mutilating of the roots, generally a loss of a considerable part of the tap root, and experience shows that in the chestnut tree this is more of an interference, and requires more time to recover from than in any of our common fruit trees, to say nothing of the occasional loss of a tree, which transplanting always involves.

When a chestnut tree is cut the stumps and roots still retain their vitality and a vigorous growth of young stems springs up, chiefly from the base of the stump. If left to themselves the stronger will smother and crowd out the weaker, but ordinarily several will remain to grow to maturity. This is still too many. They are crowded and are likely to grow crooked and imperfect. If desired for timber they should be left so close together that the growth will be thrown chiefly into the trunk, but if fruiting trees are wanted they should be gradually thinned out so that each of those remaining will have ample room for low, round-headed development.

The chestnut tree is valuable for its wood and bark as well as for its fruit. The wood is characterized for its lightness and porosity, and is specially valuable for its durability. The specific gravity averages about .45. It is porous because of the great number and large size of the vessels in the wood. These, as well as the wood cells themselves, do not become solid when the sap wood changes into heart wood, but retain more or less their open character. It thus absorbs or loses water, swells or shrinks readily, according to the condition of the air. Although light and brittle, and hence un-

suited for some uses, its superior durability makes it one of the best of our native woods for many purposes. The bark has value for tanning, although not held in as high esteem for this purpose as that of several other trees.

The fruiting of the chestnut does not ordinarily occur until the tree has become at least ten or twelve years old, and when they are crowded not until much later, and then sparingly only on its uppermost branches. Low, round-headed trees having ample room for development, are the only ones which bear early and liberally. Hence, isolated trees on the borders of woods and fields are always the most productive. Blossoming occurs from June to July, according to latitude, and the fruits mature in from two and one-half to three months. The flowers are separated; the staminate, or male, conspicuous from the long finger-like spikes of the cluster on which the whitish flowers are arranged; the inconspicuous pistillate or female flowers are in small compact clusters, each of which latter is surrounded by prickly bracts which grow rapidly after the flowers are fertilized, forming the globular bur. Apparently fertilization is accomplished by the action of the wind, and there are some facts which seem to indicate that cross-fertilization is necessary. Lack of fruitfulness is due to a variety of circumstances, and here, as with other plants, the cause must be sought for sometimes outside of the flower. The nuts are too well known to need description. They are comparatively uniform in size, but vary greatly in abundance and perfection in different years. Imperfect fertilization and insect injury are the chief causes of this.

Our native chestnut is but little variable in any respect, and has given us scarcely any varieties, the history of which is known, or which are plainly distinguished from the type.

The European chestnut, however, has not only a marked natural peculiarity in the greater size of its nuts, but has given rise to varieties which are much superior to the wild type, and are highly valued by cultivators. Over thirty have been named and the common species is said to be but little used except as stock upon which to work the others. The varieties in most frequent cultivation are esteemed for the superior quality of their fruit more than for any other reason. The trees do not grow so large as the American, and come into bearing more quickly.

Within the past few years species from Japan have been introduced into the United States. Unfortunately they do not appear to be entirely hardy on their own roots, except in the south and some favored districts in the middle states. They are quite dwarf in habit, produce nuts larger even than the European, and begin to fruit when they are but four or five years old.

These two characters, of small size and early fruitfulness, give them special value, and if they can be worked upon stocks of the American species we can secure trees which will bear earlier, and produce larger nuts than our native species. It would seem possible, also, by hybridizing, to combine the hardiness, vigor and quality of the American species with the larger size of fruit and precocious bearing of the foreign sorts. The nuts of the latter, despite their large size, are not of the best quality. They lack sweetness, and the skin is often quite bitter and astringent, but as this is easily removed, and boiling makes the meat more palatable, this method of preparation is commonly employed in foreign countries where chestnuts have long been a favorite article of food. In this country we have never looked upon them in just that light, although a great many bushels are used every year, and the supply never equals the demand. Many districts in which the trees are abundant derive a very respectable income from the sale of the nuts, and it is obvious that this is an industry which can be made far more productive and profitable than it now is, since very little effort has been made toward cultivation. Only the natural, spontaneous product has been gathered.

In raising chestnut trees from the seed special care and pains should be taken to secure fresh nuts which have not had time to become dry, or have been carefully packed so as to preserve their moisture. It is surprising how quickly they lose moisture in a warm and dry atmosphere, and, as loss of moisture means loss of germinative power, too great pains can scarcely be taken with nuts intended for seed. They may be planted in the fall or buried in the ground until spring and then planted. The former is generally the better plan. The objection commonly raised to fall planting is the danger that the nuts will be destroyed by burrowing animals. This should be anticipated by planting at least twice as many as the number of trees desired. It may be doubted whether spring planted nuts are not fully as liable to destruction by this means as are any other.

Care should be taken that they are not carelessly put so deep that the stem finds difficulty in getting into the air, nor so poorly covered that they will dry out before germination. The use of the foot in seed sowing to press the ground about the nut should be carefully observed. On rough, stony ground containing roots of various shrubs all the operations of planting are more tedious than in other situations, but success cannot be had without proper observance of them. Very bushy land must be cut and burned over before planting. It must not be supposed that because the chestnut is a forest tree it will grow anywhere. After it is once thoroughly estab-

lished it will hold its own, but in order to get a start and foothold it must have much the same help and protection which are given to any cultivated plant. The seedlings must have light and air and will not thrive in the shade nor when crowded by sprout-growth or other vegetation. Transplanting seedling trees can of course be done, but so far as our experience goes, it is always attended by a check on growth and vigor which last two years or more, and they are easily outstripped by the others.

Transplanting larger trees we have had little experience with, but it is probably no more difficult than the transplanting of oak, hickory and other trees of this class, and, where time is an object and the number desired is not large, this means would naturally be employed.

The slaty and sandy hills and mountain slopes so common throughout Pennsylvania offer excellent conditions for chestnut culture of this kind. Few of these lands are now cultivated at any profit; few are of any real value for pasturage even; many are utterly neglected and abandoned as no longer worth attention. A few acres on each farm planted to chestnuts would entail no great expense or labor, and would at least renew the wooded covering which protects the surface from washing, holds the leaves and vegetables debris, and gradually accumulates humus to enrich the soil. Few trees are more useful to the farmer in furnishing posts and other materials for farm uses; and, with proper care in thinning, trimming and protecting, they would in time become bearing trees—a chestnut orchard, as reliable a source of income as an orchard of any kind of fruit. The treatment of such an orchard would naturally vary very much with its situation. In ground easily worked, cultivation, for a few years at least, would be the easiest method of keeping down other plants and leaving the trees a clear field to occupy. In such instance close planting, only a few feet apart, would be advisable.

Where the surface is very stony or encumbered with stumps and refuse from former growth the cultivation would necessarily be limited to the immediate vicinity of the trees, and would, perhaps, be little more than cutting away about them to prevent their being smothered. It should be borne in mind, however, that neglect to do this so often and so thoroughly as is needed will result in the young trees becoming weakened and soon crowded out completely by their rivals. But where there is a natural sprout-growth of chestnut on land which is often abandoned and left to run to waste there is an excellent opportunity for securing an orchard of nut trees at a very small expense and trouble. The chestnut sprouts should be thinned out gradually until they are so far apart that they will not interfere with one another. Trees so exposed will develop short

Sprout Grafted Paragon Chestnuts, 5 years old, Marietta, Pa.

trunks and low, round-headed tops, and will come into bearing much sooner than otherwise. The trees and shrubs of other kinds should meanwhile be cut periodically, at least in so far as they directly interfere with the symmetrical development of the chestnuts, so that the latter will eventually occupy the whole ground. Had a little care of this kind been exercised over a very few only of the beautifully timbered lands of Pennsylvania after the cutting of the original growth there would now be many thousands of productive trees yielding a handsome revenue to their owners. In effect this is but giving a little attention to the second growth which appears after every cutting of chestnut land, and thus turning its energy into a particular channel. When the small amount of labor necessary to do this is considered it is surprising that more do not undertake it. It will be necessary to afford some protection from fire and trespassers, but what reasons can be given for not protecting and enforcing the rights on property of this kind as on any other?

But such sprout-growths can be treated in another way. If taken when they are still young and small they can be grafted with scions of any of the named varieties which are now offered by nurserymen.

The advantages of this method are so great, and it can be so easily applied in many parts of the State where this tree is common, that a description of what has been done will be the readiest means of understanding and appreciating it, and a guide for those who wish to undertake it.

Along the west side of the Susquehanna river, in York county, opposite Marietta, runs a low, rough mountain ridge of quartz rock, which is the hardest and least easily disintegrated of all rock materials. Where it has been cleared of brush and tree growth the surface is strewed with boulders broken off of the parent ledge. Soil can scarcely be said to exist. At best there is but a gravelly surface with here and there the loose rocks in profusion. To look at a cleared portion of it one might very naturally suppose that nothing whatever could grow upon it. Nevertheless there has been a quite liberal tree growth here, chiefly of rock oak and chestnut, and it is evident that the hillside is fit for nothing else. It has been cut over at least once, quite likely twice, and allowed to grow up to sprouts again. While chestnut was the dominant growth it was so thick and crowded that the trees never amounted to anything as nut producers. The wood was useful for posts and rails, but the owner, Mr. Engle, says he never thought it worth while to attempt to gather the few scattered nuts which they produced. About sixteen years ago he received from Mr. William L. Schaeffer, of Philadelphia, grafts of a variety of chestnut called the "Great American," since it was thought to be a large fruited form of the native American species.

These grafts were set in trees growing in his door-yard, and have now made beautiful, low, round-headed specimens strikingly like the apple tree in general appearance. They grew rapidly and bore almost every year. These trees were so closely surrounded by buildings and fences that it was not feasible to take a photograph of them, but a smaller tree, now eight years old, is shown in the frontispiece as it appeared in January. Soon they called attention to the superior character of the variety, and suggested the experiment of grafting on the young sprouts upon the hillside across the river. Accordingly the native growth was cleared away, a few acres each year, and, after a year from cutting, when the young sprouts had sprung up about each stump, the process of grafting began. The sprouts were thinned out freely so that those remaining should be as uniformly spaced as possible. These were then grafted with scions supplied from the few door-yard trees first worked. The process of grafting did not differ materially from that long employed in the propagation of the apple and other familiar fruits, but rather seems to correspond so closely to it that any one who can graft the apple can graft equally well the chestnut, although it is probable that the percentage of successful grafts with the latter will always be somewhat smaller. Care must be taken to have both stock and scion in good condition. The scion, particularly, should be dormant, and yet plump and ready to quicken and start into active growth so soon as the current between stock and graft is established. Particular time, early or late in the spring, does not seem to be essential so long as the scions are in this satisfactory condition. But, considering how easily they become impaired as the warm and sometimes dry weather of spring arrives, I much incline to favor early grafting. I have had the best success with the early set grafts. Mr. Engle, however, is inclined to pay little attention to time and to do the work when it is most convenient.

Neither does there seem to be much choice in the kind or grafting employed, excepting as that is determined by the size of the stock. In general, preference has been given to whip or tongue grafting the sprouts which are half an inch or thereabouts in diameter. This is a more rapid method than cleft grafting, and by it a closer contact with the stock can be obtained, and the grafts are less easily displaced. Should the graft fail to grow, cleft grafting the succeeding year will often be required on account of the increased size which the sprouts have reached. Grafts should be set up two or three feet from the ground; even then the tendency is to make low and broad tops. Sometimes the union is imperfect and a knob or irregular swelling shows where the grafting was done. But more commonly no dis-

tinct mark was left after two or three years time, and in many trees it was impossible to distinguish where the union had taken place. The details of such simple grafting as this it is assumed the reader is already familiar with. If he is not they may be found well described and illustrated in any of the books on Plant Propagation, such as Fuller's, page 199-222, or Barry's Fruit Garden, page 93-100.

Very much better than this, however, would be the taking of a few practical lessons from some one familiar with the matter. Simple as grafting is there is nevertheless a knack about it that can be best and most quickly obtained by practice. The after treatment has been very simple, and consisted in nothing more than a cutting of the berry bushes and other undergrowth. This has been left to mat down and decay, and has served a useful purpose as a mulch. Later it will make an accumulation of soil. There would seem to be great danger from fire in this material. That there has never been a fire in this place can be accounted for only by the careful attention which it has received and its isolation. It is also a fair question whether such a mass of broken twigs and other debris is not a means of harboring and encouraging the presence of injurious insects. In a more recently started nut orchard in the southern part of Lancaster county, where the ground is not so rough, it is Mr. Engle's intention to destroy all the undergrowth and get a surface of light pasture grass.

Occasional grafts which have contained fruit buds have knit so quickly as to have brought forth their flowers and even produced fruit in the first year. But this is very exceptional, and moreover is not desired. More commonly there has been fruiting the second year, but this also is no real advantage and is not encouraged. With the third year bearing becomes quite common, and from this on regularly increasing crops are the rule. Indeed, the trees are apt to set more fruit than they can carry and mature, and Mr. Engle's practice has been to thin them as soon as the burs are so fully formed that they foreshadow the probable crop. This is necessary to prevent the branches from being broken, if for no other reason. The nuts, it should be remembered, are three to four times as large as the native species and the burs are correspondingly heavy. This precocity of the grafted trees (for the native seldom bears before it is ten to fifteen years old) is perhaps even more pronounced than in our common domesticated fruits, and is of itself sufficient to show a great advantage in the practice of grafting. Because of it some return is had in three years from the time of doing the main part of the work, or four years from that of cutting the trees whose sprouts served as stocks. The oldest trees on the hillside referred to are now six years grafted. About twenty-five acres

have been worked over, or will have been before the current year expires; about three-fourths of this are in moderate bearing. They are all of the one variety, now called "Paragon," since it is not a pure native American, as was thought when the first name was applied. It has certain excellent characters which have been confirmed by twelve or more years during which it has been fruited. They are regularity of bearing, seldom missing a year, large size, fair to good quality (they hardly equal the native nut in sweetness, though they come very close to it), and a holding in the bur even after they are fully ripe and it has opened wide. This last quality is of considerable advantage in gathering on rough, rocky ground, where many nuts would be lost if they shelled out easily and fell among the undergrowth or into the rock crevices. The burs can be removed from the trees, taken to a smooth "floor" where the nuts can be separated at leisure. In addition to early fruitfulness grafting produces nuts of a known variety, and hence uniform size and quality. Nut culture thus becomes reduced to a system and is no longer the hit or miss matter of the wild tree. It seems quite probable moreover from the experience of a number of others, that this particular variety is not any better adapted to propagation by grafting than are other kinds, and that even the Asiatic or Japan varieties may by grafting become entirely hardy and productive also. These latter bear nuts of still larger size, but are liable to be quite deficient in quality. They vary, however, greatly among themselves, and now that they are being grafted so commonly we shall doubtless soon have these differences in quality brought out and so well known that the name chestnut will of itself be no more distinctive or expressive than is the word apple, when unaccompanied by the qualifying variety name like Baldwin or Rambo.

It goes without the saying that chestnuts are salable, and that the market has never yet been overstocked. Indeed, the market is generally quickly sold out, and this in spite of the fact that they are not perishable by any means and their is no need of forcing their sale. These larger grafted nuts are particularly attractive, since the average customer will pick out the big ones every time, and the size of the fruit outranks every other consideration.

Altogether there are several reasons why the growing of chestnuts is well worthy the attention of any one who has the facilities for it. These facilities are a light, sandy or gravelly soil which is dry or easily drained, or, better still, a natural chestnut coppice on land the rougher the better, since it can be utilized very fully by grafting after the manner described. There is a great deal of such land in Pennnsylvania. It is safe to say that it often does not pay its taxes. The same energy and care here put into the creation of a chestnut

orchard that is given to one of apples would seem to be entirely feasible, and the most promising means of making such lands productive. It need not be denied that there are some drawbacks to this business, for they occur everywhere, and often tax the ingenuity and skill of the cultivator. Some of them are common to the growing of any crop, and hence call for no special consideration here. The most formidable difficulty which has yet been met with has come from insect attacks. The chestnut tree is subject to the attack of a variety of insects, for the most part the larvae of various moths which feed upon the leaves. A number of longicorn beetles also attack the wood. But the most serious injury is done by a small weevil (Balaninus caryatripes), which perforates the young nut by means of a very long proboscis and then lays therein an egg, which develops into a footless grub. This eats into the nut, consuming a considerable part of it, and eventually escapes into the ground, where it probably passes the winter and comes out in the mature form about the time the trees are blossoming. While its precise life history has not yet been determined in detail it is probable that it varies but little from the general course just described. With fuller knowledge some specific treatment may be suggested.

It is not surprising that the rich harvest of food in the growing nut should be sought by a weevil for the support of its young. Such weevils are found for almost if not every such fruit, often several species for one kind. It is not easy to offer any practicable and efficient remedy. In gathering the nuts all infested specimens should be screened out and burned, but this will not affect the breeding in the wild trees from which they may readily pass to the cultivated. Judging from what has been done to combat the plum curculio and other weevils of this kind, jarring the trees at the time of egg laying would seem to be an effective remedy. This is commonly done by driving a heavy nail into the trunk of the tree at a convenient point for striking with a mallet. To avoid forcing such a nail too deep in the wood, a better way is to bore a half-inch hole and slip into it a snug fitting flat iron washer. Then use a removable blunt iron bolt in place of the nail. The hole would need to be reamed out every year to prevent its closing. By this device the beetles could be rapidly jarred from the trees, caught upon a sheet and destroyed.

CARE OF WOOD LAND.

BY WM. H. BUCKHOUT.

There were several severe wind storms during the summer and early fall of 1896, and an unusual number of trees were blown down. Even a casual observer must have noticed two things about these trees: first, that they were almost entirely our red and black oaks, and second, that they were more or less rotten at the heart.

Closely examined, many of them showed along their trunks defective spots which indicated the decay within. But it is often quite a surprise that trees that appear as though they would keep on growing for many years longer should so easily topple over in a storm. The red and black oaks are much more subject to disease, and hence to early failure and destruction than are any others, but, in large measure, the difficulty arises from the fact that, in our valley woodlands especially, the oaks are almost all from sprout growth. Very few are from seed. Sprouts are of deceptive value because they grow very rapidly for a few years and overtop or crowd out everything else. But they soon change in growth rate and will never make trees of full size. They not only fail to develop a strong independent root system, but are peculiarly liable to become diseased. This comes primarily from the old stump, and naturally is exerted along and up the center of the trunk, slowly destroying the heart wood. Owing to the greater ease and quickness of the early growth of the red and black oaks, and the frequent culling out of the white oaks for various purposes, our valley woodlands are, unconsciously, undergoing a marked change in varieties of trees; the poorer kinds being left in very large proportions.

There are many places where, for various reasons, it seems desirable to keep up a bit of woodland. To have the best and most productive it is necessary to exercise some care in the varieties of trees and this can scarcely be done without some labor. Some kinds, like the pines, make fair headway by natural seeding, where conditions are favorable; but the white oaks do not, as a rule. Their acorns are too easily destroyed, and the seedlings require some protection.

It is possible, however, to secure them by planting acorns directly in the woodland wherever the trees are not too thick. In the fall and early winter is the best time to do this, using some heavy tool to make an opening in the ground or among the rocks sufficient to allow covering the acorn and thus prevent—not freezing, but the rapid thawing after freezing, as well as the drying out, which are so fatal

to those which germinate on the surface. The spring will answer for this very well provided the acorns have been kept slightly moist by burying them in the ground. A few days of exposure to a dry atmosphere, no matter how cool, is sufficient to destroy their vitality.

A reasonable amount of care in planting and of subsequent protection will enable any one to slowly restore his oak woodlands and make them much more productive than they now are.

A SOIL TEST WITH FERTILIZERS.

REPORTED BY H. P. ARMSBY.

Hardly any question is more frequently asked by the intelligent farmer than "What fertilizers does my soil need?" and frequent requests for analyses of soils are received by this and doubtless by other experiment stations, the belief of the sender being that such an analysis will furnish a reply to the above question. Unfortunately, however, the methods of soil analysis have not yet been sufficiently perfected to furnish the information desired. While a chemical analysis of a soil will show the total amount of plant food present, it does not, in the majority of cases, allow us to draw any certain conclusions as to how much of this is actually available for the crop.

The most satisfactory, and, indeed, usually the only method by which we can at present determine the needs of a soil is to ask the question of the soil itself by growing a crop upon it with different kinds of fertilizers and noting the result. Such soil tests with fertilizers have in many cases given results of much immediate practical value for the locality in which they were undertaken. As a rule, however, farmers have looked upon such experiments as something too costly and complicated for them to undertake and consequently they have perforce been content to use fertilizers in a more or less haphazard manner, and in many cases, no doubt, at a great financial disadvantage.

As a matter of fact, however, such experiments while, of course, demanding care, exactness and attention, are neither so difficult nor so expensive as is often supposed. The purpose of the present publication is to describe such an experiment, the results of which were reported to this Station by Mr. R. P. Lovett, Jr., of

Fallsington, Bucks county, Pa. This experiment was undertaken and carried through by Mr. Lovett for his own information without consultation with or assistance from the Station. It is reported here both for its intrinsic interest and especially as illustrating a method by which, without much expenditure of time or money, the farmer may obtain information of great value to himself regarding his own soil. The results of Mr. Lovett's experiments may be briefly summarized as follows:

SUMMARY OF RESULTS.

A suitable combination of fertilizers as compared with an unsuitable one gave an increased profit per acre in two experiments of $47.24 and $54.71 respectively.

For potatoes, Mr. Lovett's soil needs especially potash and to a slightly less degree phosphoric acid.

The use of nitrogen in a soluble form under favorable conditions paid an average profit of $5.44 per acre. Under unfavorable circumstances, no increased crop resulted and it was used at a financial loss of $7.14 per acre.

Phosphoric acid without potash gave an increased profit per acre in two experiments, of $2.90 and $7.72 respectively.

Potash without phosphoric acid gave an increased profit per acre in the two experiments of $6.73 and $17.39 respectively.

Phosphoric acid and potash used together gave an increased profit per acre in the two experiments of $40.17 and $51.02 respectively. In other words, neither the potash nor the phosphoric acid was able to produce its full effect except in the presence of the other, and the profit per acre arising simply from using the two together instead of separately amounted in the two experiments to $30.54 and $25.91 respectively.

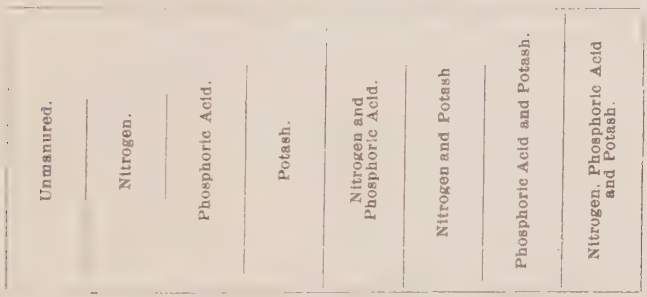
The average potato fertilizer sold in Pennsylvania, as compared with the home-mixed complete fertilizer used in these experiments, would have supplied but 44.4 per cent. as much of the most needed element (potash), 148.8 per cent. as much phosphoric acid and 50 per cent. as much nitrogen.

It is practicable for the farmer to ascertain the needs of his soil as regards fertilizers by means of comparatively simple and inexpensive field experiments and thus to avoid wasting money in the unnecessary purchase of artificial fertilizers.

DETAILS OF THE EXPERIMENT.

Of the three ingredients of plant food which are most likely to be deficient in the soil and for the sake of which commercial fertilizers are purchased, namely, nitrogen, phosphoric acid and potash, any one or two or all three may be already present in the soil in sufficient

quantity. In order to ascertain the needs of the soil, therefore, we must try each of these ingredients singly and also by twos, as well as all three together. Including an unmanured plot for comparison, this would require eight plots, which might be arranged somewhat as in the following diagram:



Sources of these Ingredients. — Dealers in agricultural chemicals offer a variety of substances which will furnish these three ingredients separately. For such a soil test as we are now speaking of, the choice among these is largely a question of convenience. After we find out by such a field trial what the soil needs, it is time enough to investigate the question of the relative value of different forms. In the experiment under consideration, nitrogen was furnished by nitrate of soda, containing on the average 15 per cent. of nitrogen and costing $50.00 per ton. Phosphoric acid was furnished by dissolved bone black, which averages about 15 per cent. of phosphoric acid and costs $23.00 per ton. Potash was used in the form of muriate of potash, averaging 50 per cent. of actual potash and costing $45.00 per ton. The amounts used were: nitrate of soda, 300 pounds per acre; dissolved bone black, 600 pounds per acre; muriate of potash, 300 pounds per acre.

Size of Plots.—The plots used in this experiment were uniformly 1-150 of an acre. This is a much smaller plot than is ordinarily recommended and it probably would have been better had they been larger. In our own experimenting, we seldom used a plot smaller than 1-20 of an acre, but German experimenters have used with success plots as small as 1-80 of an acre.

Methods of Application.—Two methods of applying the fertilizers were experimented upon, viz., on a level with the seed pieces and on the surface over the seed pieces. In other words, there were really two experiments side by side, the same unmanured plot, however, being common to both. One plot was also used for a test of a brand of commercial fertilizer, but the results on this plot are not included in this discussion.

Seeding, Weather, Etc.- The seed potatoes were cut to one or two eyes and were planted in rows three feet apart and twelve inches apart in the row. The following notes were taken with regard to the weather:

May 24, potatoes planted.
May 27, light sprinkle.
June 5, good rainfall.
June 21, light rainfall.
June 27, good rainfall.
June 28, good rainfall.
July 5, heavy rainfall.
July 16, moderate rainfall.
July 30, light shower.
August 4, moderate shower.
August 7, moderate shower.
August 11, moderate shower.
September 16, very light shower.

Mr. Lovett adds: "If the potatoes had been planted three weeks earlier, I feel confident that all of the rows would have yielded better, particularly the potash ones, but owing to pressure of other work they could not be planted sooner."

Yields secured.— The following tables give the results as reported to the Station by Mr. Lovett, each of the two experiments being given separately. The observed yields were corrected for the number of missing plants and the yield and profit per acre computed from these corrected results. Large potatoes were valued at 42 cents per bushel and small ones at 10 cents. The correction for missing plants is always an uncertain one, and in the discussions which follow it has been thought better to omit it and draw conclusions directly from the plot yields. The correction, however, is small and really and makes very little practical difference in the teaching of the experiment.

Fertilizer Experiments on Potatoes— Fertilizer applied on a Level with the Seed.

Plat.	Fertilizers Applied.	Abbreviations.	Pounds per plat.	Pounds per acre.	Yield, pounds per plat.	Yield per acre in bushels, corrected for missing plants.			Cost of fertilizer per acre.	Value of yield.	Surplus.	Per cent. of small tubers.	Color of plants.	Missing plants.
						Large.	Small.	Total.						
1	Nitrate of Soda,	N	2	300	28	45	29	74	$7 50	$21 80	$14 30	39	Dark green.	8 per ct.
2	Dissolved Bone-Black,	P	4	600	35	58	34	92	6 90	27 76	20 86	37	Dark green.	1/2
3	Muriate of Potash,	K	2	300	39	72	25	97	6 75	32 74	25 99	25	Light,	2
4	Nitrate of Soda,	N P	2-4	300-600	35	68¾	23¾	92	14 40	31 12	16 72	25	Very dark,	7
5	Dissolved Bone-Black,													
6	Nitrate of Soda,	N K	2-2	300-300	39	69	30	99	14 25	31 98	17 73	30	Light,	4
7	Muriate of Potash,													
8	Dissolved Bone-Black	P K	4-2	600-300	75	173	18	191	13 65	74 46	60 82	9	Light,	4
9	Muriate of Potash,													
10	Nitrate of Soda,	N P K	2-4-2	300-600-300	90	202½	26½	229	21 15	87 70	66 55	11	Medium,	4
11	Dissolved Bone-Black,													
16	Muriate of Potash,													
	Not any,	0	. . . . .	. . . . .	27	41	28	69	. . . . .	20 00	20 00	40	Medium,	4

Fertilizer Experiments on Potatoes—Fertilizer applied on the Surface

Plat.	Fertilizers Applied.	Abbreviations.	Pounds per plat.	Pounds per acre.	Yield, pounds per plat.	Yield per acre in bushels, corrected for missing plants.			Cost of fertilizer per acre.	Value of yield.	Surplus.	Per cent. of small tubers.	Color of plants.	Missing plants.
						Large.	Small.	Total.						
9	Nitrate of Soda,	N.	2	300	37	65	31	96	$7 50	$30 40	$22 90	32	Dark green,	6 per ct.
10	Dissolved Bone Black,	P.	4	600	41½	71	33	104	6 90	33 12	26 22	31	Dark green,	4
11	Muriate of Potash,	K.	2	300	49	95	31	126	6 75	43 00	36 25	24	Light,	5
12	Nitrate of Soda, / Dissolved Bone Black,	N. P.	2-4	300-600	62	137	17	154	14 40	59 24	44 84	11	Very dark,	2
13	Nitrate of Soda, / Muriate of Potash,	N. K.	2-2	300-300	59	132	18	150	14 25	57 24	42 99	12	Medium,	4
14	Dissolved Bone Black, / Muriate of Potash,	P. K.	4-2	600 300	86	188	30	218	13 65	81 96	68 31	14	Medium,	3
15	Nitrate of Soda / Dissolved Bone Black, / Muriate of Potash,	N. P. K.	2 4-2	300-600-300	79	170	33	203	21 15	74 70	53 55	16	Medium,	5
16	Not any,	0			27	41	28	69		20 00	20 00	40	Medium,	4

WHAT THE RESULTS SHOW.

Even a casual study of the above figures shows that the application of the nitrogen gave a comparatively slight result, especially in the first of the two experiments, while phosphoric acid and potash applied alone gave somewhat more favorable results. Little further advantage was derived from the addition of nitrogen to either phosphoric acid or potash. A considerably greater gain resulted from the use of phosphoric acid and potash together and, in the second experiment, a further gain resulted from the addition of nitrogen to phosphoric acid and potash.

The teachings of the experiment may be made much clearer, however, by certain comparisons which lead to the detection and elimination of accidental errors. The method of making this comparison has been worked out by Prof. Liebscher, of the University of Göttingen.* It is based upon the fact that, in an experiment made in this way, we can compute the effect of any one ingredient from four different pairs of plots. The method may be best explained by actually applying it to these experiments.

Discussion of the First Experiment.

Taking first the results for nitrogen, and using for convenience the abbreviations given in the above tables for the different fertilizers —namely, "O" for unmanured, "N" for nitrogen, "P" for phosphoric acid and "K" for potash ("K" being the chemical symbol for the metal potassium, the basis of potash)—we find that we can make the following comparisons of plots with and without nitrogen:

Plot 1, . . . N.	Plot 4, . . . N and P.	Plot 5, . . . N and K.	Plot 8, . . . N, P and K.
Plot 16, . . . O.	Plot 2, . . . P.	Plot 3, . . . K.	Plot 7, . . . P and K.

The four plots in the upper row differ from those in the lower row only in the fact that they received nitrogen. Consequently, by subtracting the yields of the plots in the lower row from those of the plots in the upper row, we shall find how much the yield was increased in each case by the addition of nitrogen.

The same eight plots may also be grouped so as to make similar comparisons for phosphoric acid and for potash. Thus, for phosphoric acid, we have the following comparisons:

Plot 2, . . . P.	Plot 4, . . . P and N.	Plot 7, . . . P and K.	Plot 8, . . . N, P and K.
Plot 16, . . . O.	Plot 1, . . . N.	Plot 3, . . . K.	Plot 5, . . . N and K.

Here again by subtracting the lower line from the upper, we shall get the effect of adding phosphoric acid. Similarly, for potash, we have the following comparisons:

Plot 3, . . . K.	Plot 5, . . . N and K.	Plot 7, . . . K and P.	Plot 8, . . . N, P and K.
Plot 16, . . . O.	Plot 1, . . . N.	Plot 2, . . . P.	Plot 4, . . . N and P.

Making the substractions, we obtain the following figures for the effects of nitrogen, phosphoric acid and potash. The figures show the

*Journal für Landw. 43, 49.

gain in pounds per plot and, for the reason stated above, have not been corrected for the missing plants:

Effect of Nitrogen.

Yield without Nitrogen.		Yield with Nitrogen.		Gain with Nitrogen, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27	N	28	1
P	35	PN	35	0
K	39	KN	39	0
PK	75	PKN	90	15

Effect of Phosphoric Acid.

Yield without Phosphoric Acid.		Yield with Phosphoric acid.		Gain with Phosphoric acid, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27	P	35	8
N	28	NP	35	7
K	39	KP	75	36
KN	39	KNP	90	51

Effect of Potash.

Yield without Potash.		Yield with Potash.		Gain with Potash, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27	K	39	12
N	28	NK	39	11
P	35	PK	75	40
PN	35	PNK	90	55

These results may be summarized as follows for the purpose of more convenient comparison:

Effects of Fertilizers.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.
O	1	O	8	O	12
P	0	N	7	N	11
K	0	K	36	P	40
PK	15	KN	51	PN	55

From the above figures we see again that potash plainly produced the greatest effect, phosphoric acid standing next, while nitrogen showed practically no effect in three cases out of four. We notice, however, that the figures in the last line of the last table are uniformly 15 pounds higher than those of the third line. This coincidence indicates an accidental error of 15 pounds. Either the yield of Plot 8 (NPK) was too high or those of three other plots, namely, No. 4 (NP), No. 5 (NK) and No. 7 (PK), were each too low by 15 pounds. It is far more likely that one plot should be too high by 15 pounds than that three should be too low by exactly the same amount. Moreover, the assumption that the yield of Plot 15 was too high harmonizes the results, while the contrary assumption has exactly the contrary effect. Assuming, then, that the true yield of Plot 8 (NPK) was 75 instead of 90, we have the following as the corrected results for the effects of the different fertilizers:

Effects of Fertilizers—First Correction.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot
O	1	O	8	O	12
P	0	N	7	N	11
K	0	K	36	P	40
PK	0	KN	36	PN	40

The results now appear strikingly uniform with the exception of a difference of one pound between the first and second lines. Such a small difference is hardly of much importance, but it may be eliminated either by the assumption that the yield of the nothing plot was one pound too low or that that of the nitrogen plot was one pound too high. Chosing the latter alternative, in order not to affect the comparisons of the second experiment, in which the same nothing plot was used, and assuming the correct yield of Plot 1 to have been 27 pounds instead of 28, we have the following as the effects of the different ingredients used:

Effects of Fertilizers—Second Correction.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.
O	0	O	8	O	12
P	0	N	8	N	12
K	0	K	36	P	40
PK	0	KN	36	PN	40

The corrected yields of each plot, accordingly, would be as follows:

Corrected Yields Per Plot.

Number of Plot.	Fertilizer.	Corrected Yield, pounds per plot.
1	N	27
2	P	35
3	K	39
4	NP	35
5	NK	39
7	PK	75
8	NPK	75
16	O	27

CONCLUSIONS.

The teachings of the experiment are now perfectly plain and may be briefly stated, as follows:

Nitrogen produced no effect, either alone or in any combination.

Phosphoric acid, used either alone or with nitrogen, resulted in a gain of eight pounds per plot.

Potash used either alone or with nitrogen, resulted in a gain of twelve pounds per plot.

Phosphoric acid added to potash (with or without nitrogen) resulted in a gain of thirty-six pounds per plot.

Potash added to phosphoric acid (with or without nitrogen) resulted in a gain of forty pounds per plot.

Potash and phosphoric acid used together produced a total gain over the unmanured plot of forty-eight pounds.

From the results of this experiment, we conclude that the soil experimented upon was deficient both in potash and phosphoric acid, and that consequently neither one of these was able to produce its full effect except when used with the other. We should also conclude that the soil had a sufficient supply of nitrogen for the needs of the potato plant and that the use of nitrogenous fertilizers was unnecessary, but this conclusion is modified somewhat by the results of the second experiment.

FINANCIAL RESULTS.

The most important practical question connected with the use of fertilizers is, does it pay?

Using the corrected yields per acre, and taking Mr. Lovett's prices, as already stated, viz:

Large potatoes, ... 42 cts. per bushel.
Small potatoes, ... 10 cts. per bushel.
Nitrate of soda, ... $50 00 per ton.
Dissolved bone black, ... 23 00 per ton.
Muriate of potash, ... 45 00 per ton.

we get the following statement of the financial results of the experiment:

Financial Results—First Experiment.

Number of plot.	Fertilizer.	Corrected yield per acre in bushels of 60 pounds.			Value of crop per acre.	Gain over unmanured.	Cost of fertilizer per acre.	Gain (+) or loss (—) from use of fertilizer.
		Large.	Small.	Total.				
1	N	41.2	26.3	67.5	$19 93	$0 22	$7 50	—$7 28
2	P	55.1	32.4	87.5	26 38	6 67	6 90	— 0 23
3	K	73.1	24.4	97.5	33 14	13 43	6 75	+ 6 68
4	NP	65.6	21.9	87.5	29 74	10 03	14 40	— 4 37
5	NK	68.2	29.3	97.5	31 57	11 86	14 25	— 2 39
7	PK	170.6	16.9	187.5	73 32	53 61	13 65	+39 96
8	NPK	166.9	20.6	187.5	72 16	52 45	21 15	+31 30
16	O	40.5	27.0	67.5	19 71	.....	.....	.....

In the above financial statement, the weights of large and small tubers respectively have been computed from the total corrected yield by the use of the percentages reported by Mr. Lovett. A glance at these percentages in the original tables, however, suggests at once that they also may need correction. For this purpose, we can apply the same method that we have already used for correcting the yields. In doing this it will be convenient to compare the percentages of large tubers rather than those of the small tubers for the sake of avoiding negative quantities. The results, as they stand, give us the following comparisons:

Effect of Fertilizers on Percentage of Large Tubers.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.
O	1	O	3	O	15
P	12	N	14	N	9
K	— 5	K	16	P	28
PK	— 2	NK	19	NP	14

Without going into all the details of the corrections, it may suffice to say that the comparison indicates that the reported percentages of large tubers contained in the following accidental errors:

Plot 2 (P), 11 per cent. too small.

Plot 5 (NK), 6 per cent. too small.

Plot 8 (NPK), 3 per cent. too small.

Making these corrections, the effects of nitrogen, phosphoric acid and potash become substantially hamonious, as shown in the following table, potash and phosphoric acid having each increased the percentage of large tubers by about the same amount, while nitrogen had practically no effect:

Effect of Fertilizers on Percentage of Large Tubers—Corrected.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.
O	1	O	14	O	15
P	1	N	14	N	15
K	1	K	16	P	17
PK	1	NK	16	NP	17

The corrected percentage of small tubers would then be as follows:

Corrected Percentage of Small Tubers.

Number of Plot.	Fertilizer.	Percentage of Small Tubers.
1	N	39
2	P	26
3	K	25
4	NP	25
5	NK	24
7	PK	9
8	NPK	8
16	O	40

Applying these corrected percentages to the corrected yields already computed, we get the following corrected statement of the financial results:

Financial Results of First Experiment—Corrected Percentage of Small Tubers.

Number of plot.	Fertilizer.	Corrected yield per acre in bushels of 60 pounds.			Value of crop per acre.	Gain over unmanured.	Cost of fertilizer per acre.	Gain (+) or loss (—) from use of fertilizer.
		Large.	Small.	Total.				
1	N	41.2	26.3	67.5	$19 93	$0 22	$7 50	—$7 28
2	P	64.8	22.7	87.5	29 49	9 78	6 90	+ 2 88
3	K	73.1	24.4	97.5	33 14	13 43	6 75	+ 6 68
4	NP	65.6	21.9	87.5	29 74	10 03	14 40	— 4 37
5	NK	74.1	23.4	97.5	33 46	13 75	14 25	— 0 50
7	PK	170.6	16.9	187.5	73 32	53 61	13 65	+39 96
8	NPK	172.5	15.0	187.5	73 96	54 25	21 15	+33 10
16	O	40.5	27.0	67.5	19 71	. . . . .	. . . . .	. . . . .

Whichever of the two financial statements given above we accept as the more correct, the main teaching of the experiment remains the same. There is a loss in every case in which nitrogen was used, owing to its high cost and failure to produce any effect. Phosphoric acid alone shows, in the second table, a slight profit, and potash a somewhat larger one, while a combination of phosphoric acid and potash resulted in a gain of practically $40 per acre, which was cut down by the addition of nitrogen to a trifle over $33.

SUMMARY OF FIRST EXPERIMENT.

The use of nitrogen, whether alone or added to the other fertilizers, resulted in an average loss of $7.14 per acre.

The use of phosphoric acid produced an average gain of $2.90 per acre.

The use of potash produced an average gain of $6.73 per acre.

The use of phosphoric acid and potash together (with or without nitrogen) resulted in an average gain of $40.17 per acre.

The profit from the use of phosphoric acid and potash together, as compared with the aggregate profits of the two used separately showed an increase of $30.54 per acre.

The most suitable combination of fertilizers resulted in a profit of $39.96 per acre, while an unsuitable manuring resulted in a loss of $7.28 per acre. In other words, the knowledge acquired by this simple experiment was worth $47.24 per acre for each acre in potatoes.

Second Experiment—Surface Application.

The reported results of this experiment have already been given. The conclusions from them do not appear quite so clear as in the first case. If, however, we make the same comparisons as in the first experiment, basing them upon plot results, we shall find the teachings of the experiment become very plain.

The apparent effect of each ingredient is shown in the following three tables:

Effect of Nitrogen.

Yield without Nitrogen.		Yield with Nitrogen.		Gain with nitrogen, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27.0	N	37.0	10.0
P	41.5	PN	62.0	20.5
K	49.0	KN	59.0	10.0
PK	86 0	KNP	79.0	—7.0*

* Loss

Effect of Phosphoric Acid.

Yield without Phosphoric Acid.		Yield with Phosphoric Acid.		Gain with Phosphoric acid, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27.0	P	41.5	14.5
N	37.0	NP	62.0	25.0
K	49.0	KP	86.0	37.0
KN	59.0	KNP	79.0	20.0

Effect of Potash.

Yield without Potash.		Yield with Potash.		Gain with Potash, pounds per plot.
Fertilizer.	Yield, pounds per plot.	Fertilizer.	Yield, pounds per plot.	
O	27.0	K	49.0	22.0
N	37.0	NK	59 0	22 0
P	41.5	PK	86.0	44.5
PN	62 0	PNK	79.0	17.0

Summarizing these as before, we have the following figures:

Effects of Fertilizers.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.
O	10	O	14.5	O	22.0
P	20.5	N	25.0	N	22.0
K	10.0	K	37.0	P	44.5
PK	—7.0*	KN	20.0	PN	17.0

*Loss.

These results are much more irregular than in the first experiment and differ from those in showing a gain from the application of nitrogen in every case but one. That there should be an actual loss from the application of nitrogen is unlikely. The probability is that this result indicates an accidental error of at least 17 pounds. Under the figures for phosphoric acid, we notice a corresponding difference of 17 pounds between the third and fourth lines. These facts indicate that the yield of Plot 15, as reported, is 17 pounds too small, that is, that it should be 96 instead of 79. Making this correction, the results stand as follows:

Effects of Fertilizers—First Correction.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.
O	10.0	O	14.5	O	22.0
P	20.5	N	25.0	N	22 0
K	10.0	K	37.0	P	44 5
PK	10.0	KN	37.0	PN	34 0

Under the effect of nitrogen, we still find a discrepancy of 10.5 pounds in the second line, while we note the same discrepancy also under the effect of phosphoric acid between lines one and two, and also under potash between lines three and four. This is most simply explained by the assumption that the yield of Plot 12 (NP) is 10.5

pounds too high—that is, that it should have been 51.5 instead of 62. Making this second correction, we have the following results, which are strikingly uniform:

Effects of Fertilizers—Second Correction.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.	When added to	Gain, pounds per plot.
O	10.0	O	14.5	O	22.0
P	10.0	N	14.5	N	22.0
K	10.0	K	37.0	P	44.5
PK	10.0	KN	37.0	PN	44.5

The corrected yields per plot would accordingly be as follows:

Corrected Yields.

Number of Plot.	Fertilizer	Corrected Yield. Lbs. per plot.
9	N	37.0
10	P	41.5
11	K	49.0
12	NP	51.5
13	NK	59.0
14	PK	86.0
15	NPK	96.0
16	O	27.0

CONCLUSIONS.

The conclusions to be drawn from these results are now very obvious and may be formulated as follows:

Nitrogen, alone or added to potash or phosphoric acid, or both, produced a gain of 10 pounds.

Phosphoric acid, alone or added to nitrogen, produced a gain of 14.5 pounds.

Phosphoric acid added to potash (with or without nitrogen) produced a gain of 37 pounds.

Potash, alone or added to nitrogen, produced a gain of 22 pounds.

Potash added to phosphoric acid (with or without nitrogen) produced a gain of 44.5 pounds.

Nitrogen, phosphoric acid and potash applied together produced a total gain of 69 pounds.

These results are similar to those of the first experiment in that potash produced the greatest result, phosphoric acid the next greatest, and a mixture of the two notably more than either one separately. They differ from those of the first experiment in two points: First, that nitrogen produced an effect, and second, that the effect of each of the three ingredients when used alone was larger than in the first trial. In the case of phosphoric acid and potash used to-

gether, the difference in effect as compared with the first experiment is comparatively slight.

The difference in the result of the two experiments can not be explained with certainty, but it is not impossible that the nitrate of soda in the first experiment may have been washed down out of reach of the plants by the rains of June, while that applied upon the surface may have still remained, in part at least, where it could be utilized, while the absorbtive power of the soil for phosphoric acid and potash may have prevented these from leaching out to any considerable extent. On the whole, it seems likely that the results of the second experiment better represent the general needs of the soil as to nitrogen than do those of the first, since it is easier to imagine accidental reasons which should prevent the nitrogen from producing an effect in the first experiment than to conceive of any which should have enabled it to produce an abnormal effect in the second.

FINANCIAL RESULTS.

The financial results of this experiment are shown by the following table, in which the percentage of large and small tubers is as reported by Mr. Lovett:

Financial Results—Second Experiment.

Number of plot.	Fertilizer.	Corrected yield per acre in bushels of 60 pounds.			Value of crop per acre.	Gain over unmanured.	Cost of fertilizer per acre.	Gain from use of fertilizer.
		Large.	Small.	Total.				
9	N	62.9	29.6	92.5	$29 38	$9 67	$7 50	$2 17
10	P	71 6	32.2	103.8	33 29	13 58	6 90	6 68
11	K	93.1	29.4	122.5	42 04	22 33	6 75	15 58
12	NP	114.6	14.2	128 8	49 55	29 84	14 40	15 44
13	NK	129.8	17.7	147.5	56 29	36 58	14 25	22 33
14	PK	184 9	30.1	215.0	80 68	60 97	13 65	47 32
15	NPK	201 6	38.4	240.0	88 52	69 23	21 15	48 08
16	O	40.5	27.0	67.5	19 71	. . . . .	. . . . .	. . . . .

Here again, however, there arises the question of possible errors in the percentage of large and small tubers and we may apply the same method of correcting these as in the previous cases. The apparent effects of nitrogen, phosphoric acid and potash upon the percentage of large tubers were as follows:

Effects of Fertilizers upon Percentage of Large Tubers.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.
O	8	O	9	O	16
P	20	N	21	N	20
K	12	K	10	P	17
PK	—2	NK	—4	NP	—5

Without going into all the details of the comparison, a study of these figures reveals the following as probable accidental errors, viz: the percentage of large tubers on Plot 13 (NK), too large by 2 per cent.; that of Plot 12 (NP), too large by 11 per cent.; that of Plot 15 (NPK), too small by 12 per cent. Applying these corrections we have the following figures for the effects of the fertilizers and for the corrected percentages of small tubers:

Effects of Fertilizers on Percentage of Large Tubers.

Effect of Nitrogen.		Effect of Phosphoric Acid.		Effect of Potash.	
When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.	When added to	Increased per cent. of large tubers.
O	8	O	9	O	16
P	9	N	10	N	18
K	10	K	10	P	17
PK	10	NK	10	NP	18

Corrected Percentage of Small Tubers.

Number of Plot.	Fertilizer.	Percentage of Small Tubers.
9	N	32
10	P	31
11	K	24
12	NP	22
13	NK	14
14	PK	14
15	NPK	4
16	O	40

On the basis of these corrected figures the financial results would be as follows:

Financial Results of Second Experiment—Corrected Percentage of Small Tubers.

Number of plot.	Fertilizer.	Corrected yield per acre in bushels of 60 pounds.			Value of crop per acre	Gain over unmanured.	Cost of fertilizer per acre.	Gain from use of fertilizer.
		Large.	Small.	Total.				
9	N	62.9	29.6	92.5	$29 38	$9 67	$7 50	$2 17
10	P	71.6	32.2	103.8	33 29	13 58	6 90	6 68
11	K	93.1	29.4	122.5	42 04	22 33	6 75	15 58
12	NP	100.5	28.3	128.8	45 04	25 33	14 40	10 93
13	NK	126.8	20 7	147 5	55 33	35 62	14 25	21 37
14	PK	184.9	30.1	215.0	80 68	60 97	13 65	47 32
15	NPK	230.4	9.6	240.0	97 74	78 03	21 15	56 88
16	O	40.5	27.0	67.5	19 71	.....	.....	.....

SUMMARY OF SECOND EXPERIMENT.

The use of nitrogen resulted in a profit of from $2.17 to $9.56 per acre, according to the combination in which it was used.

The use of phosphoric acid resulted in a gain of $7.72 per acre.

The use of potash resulted in a gain of $17.39 per acre.

The use of phosphoric acid and potash together produced a gain of $51.02 per acre.

The best combination of fertilizers resulted in a gain of $56.88 per acre, while an unsuitable fertilizer produced a gain of only $2.17 per acre, or a difference in the effects of $54.71 per acre for every acre of potatoes grown on this soil.

General Conclusions.

From these two experiments taken together, we may fairly conclude that, for potatoes, the soil experimented upon needs especially potash, and to a somewhat less degree, phosphoric acid. Soluble nitrogen under favorable circumstances will apparently produce sufficient gain to more than cover its cost, while under unfavorable conditions it will produce no result and, therefore, be used at a loss. The effect of nitrogen being thus shown to be, at best, rather small, it would seem that instead of purchasing costly artificial supplies of nitrogen, it would be better policy upon this soil, if potatoes are to be grown extensively, to secure the needed supplies of nitrogen from the atmosphere by the cultivation of leguminous crops, either used as green manuring or as food for stock, and confine the purchase of artificial fertilizers to phosphoric acid and potash. It seems altogether probable that such a method of treatment would suffice to keep the supply of nitrogen in the soil up to a point at which purchased mineral fertilizers would yield their best returns.

A very important point is the necessity of using phosphoric acid and potash together. This may perhaps be most plainly shown by the following tabulated statement of the comparative financial results obtained by using these alone and in combination:

	First experiment.	Second experiment.
Average profit from use of phosphoric acid without potash.	$2 90	$7 72
Average profit from use of potash without phosphoric acid.	6 73	17 39
Total, ...	$9 63	$25 11
Average profit from use of phosphoric acid and potash together. .	40 17	51 02
Gain due to combined use, ...	$30 54	$25 91

It should perhaps be added that the results of these trials are not in accord with those of numerous experiments by Professor Liebscher upon the potato. In his experiments he found that, as a rule, potash was the ingredient most needed, exactly as in these experiments, but that the ingredient which took second place was usually nitrogen, while phosphoric acid generally produced little or no effect This difference between these results and those of Professor Liebscher, however, simply serves to illustrate the necessity of studying

the individual soil. It so happens that Mr. Lovett's soil is, according to the testimony of these experiments, particularly poor in available phosphoric acid, and consequently this ingredient produces a marked effect, while, on the other hand, it must be fairly well supplied with nitrogen. Had Mr. Lovett attempted to apply Professor Liebscher's general result to his own soil, the consequence would have been a double loss—first, in unnecessary purchase of nitrogen and, second, in not applying the phosphoric acid necessary to bring out the full effect of the potash.

"POTATO FERTILIZERS."

It may be of some interest to compare the amounts of nitrogen, phosphoric acid and potash applied in these experiments with those contained in the so-called "potato fertilizers" largely offered by various fertilizer firms. The average of forty-seven samples of such fertilizers analyzed in this State during the first half of 1895 shows the following percentages:

Nitrogen, ... 1.86 per cent.
Total phosphoric acid, ... 11.16 per cent.
Potash, ... 5.55 per cent.

Twelve hundred pounds per acre of a fertilizer of this composition would have contained the following amounts of these ingredients, as compared with those contained in the 1,200 pounds of mixed chemicals per acre applied to plots 8 to 15 in these experiments:

	Average potato fertilizer.	Mixed chemicals.
	Pounds.	*Pounds*
Nitrogen,	22.3	48
Phosphoric acid,	133.9	90
Potash,	66.6	150

That is, the average potato fertilizer would have supplied only 44.4 per cent. as much potash as was used with profit in these trials, while it would have supplied 148.8 per cent. as much phosphoric acid as was here used and almost exactly half as much nitrogen. It is not asserted that the proportions of the three ingredients used in these experiments are the best possible, but these figures do indicate that while a special potato manure may produce excellent results, it is nevertheless very possible that it may supply certain ingredients in excess and may be deficient in others as compared with the needs of a particular soil.

It may also be noted that the average of these "potato fertilizers" diverges even more widely from Liebscher's general result noted above than it does from the particular results obtained by Mr. Lovett.

While it supplies considerable potash it is rather low in nitrogen, and on the other land contains a relatively very large proportion of phosphoric acid as compared with the usual demands of the potato crop.

Experiments by Farmers.

One of the main objects which has been had in view in reporting this experiment is to show that it is possible for the intelligent farmer, with the means at his command, to ascertain with a very fair degree of certainty what ingredients of commercial fertilizers are most needed upon his soil for any particular crop. The conducting of an experiment involving the use of only eight small plots and not necessarily continuing for more than a year or two would be a small price to pay for knowledge which may save the unnecessary expenditure of large amounts of money for fertilizing ingredients already present in the soil in more than sufficient quantity. In these days of close competition and small margin of profit, it is the farmer who, avoiding every unnecessary expenditure, best adapts his measures to the end in view who will succeed. No farmer can afford to spend his hard-earned dollars to purchase fertilizing materials without knowing, first, that he receives the value of his money in a commercial sense, and second, that the material which he buys at a fair commercial price is the exact material needed for his soil and crop. The system of fertilizer inspection and control administered by the State Department of Agriculture ensures that, if he intelligently uses the information which it furnishes, he will receive the full commercial value of his money. Experiments like the one described in the preceding pages will help him to acquire the necessary knowledge of the agricultural value of fertilizers and lead to a freer and more intelligent, and therefore more profitable, use of commercial fertilizers.

Experiments of this sort might very well be made co-operative, since single experiments, well conducted, might give results of value to a large number of individuals, while the necessary cost to the individual would thus be materially reduced. The writer ventures to suggest that agricultural organizations, such as granges, alliances and farmers' clubs, might find a very useful and profitable field of work in the management of such local experiments, and that in particular the County Agricultural Societies might be of much service to their respective counties by aiding in developing and encouraging the study by this method of the needs of the soils in their respective districts.

The Experiment Station will be very glad to advise with any individuals or organizations who may contemplate undertaking such experiments. It cannot at present bear any of the expenses of the

work nor undertake its direct supervision, but it will furnish directions for conducting the work to any who may desire, will aid in securing the necessary fertilizers and will undertake the discussion of any results sent to it upon the plan illustrated in this bulletin. It is the writer's firm belief that any individual or society undertaking such work will find itself richly repaid by the knowledge and experience which it will thereby gain.

GENERAL FERTILIZER EXPERIMENTS.

BY ENOS H. HESS.

In the annual report for 1894, pp. 258–281, a summary of the results of twelve years' work, covering three complete four-year rotations was presented, showing the gain or loss from the different combinations and amounts of fertilizer used.

During the season of 1896, the experiment was continued according to the original plan, as follows:

Plan of the Experiment.

"This experiment, embracing four tiers of 36 one-eighth acre plots each, was begun in 1881 for the purpose of studying:

(a) The comparative effect of single valuable ingredients of commercial fertilizers;

(b) The comparative effect of complete and incomplete fertilizers;

(c) The comparative effect of different forms of nitrogen;

(d) The comparative economic effect of different quantities of nitrogen;

(e) The effect of commercial fertilizers compared with barn-yard manure, lime and plaster;

(f) Effect of lime, ground limestone and plaster;

(g) The permanency of effect of the different fertilizers;

(h) Effect of various fertilizers on the growth of the different staple crops;

(i) Effect of the various fertilizers upon the relation of grain to straw;

(j) The effect of continuous cropping without manure;

Full details of the methods of conducting these experiments may be obtained by referring to the College reports for 1882 and 1883, the latter of which was printed in the Agriculture of Pennsylvania for that year, and also to bulletins Nos. 1, 2, 8, 9 and 14.

The soil upon which these experiments have been conducted is a limestone clay loam of about eight inches in depth, through which fragments of flint are thickly scattered. It has good natural underdrainage and contains a fair supply of organic matter. The surface soil is fairly uniform in fertility and depth, but the subsoil varies greatly in depth.

The crops used consisted of corn, oats, wheat and grass—mixture of clover and timothy—occupying the land in the order named. The fertilizers were applied but twice during the four years required for a complete rotation, viz., to the corn and to the wheat, with the exception of lime on plots 22 and 23, which has been applied to the corn only.

Prior to 1881 the land was used for miscellaneous field experiments, and since that time the occupation of the land is shown in the subjoined table:

Tier.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
One, ...	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn.
Two, . . .	Corn, . .	Oats, . .	Wheat, .	Grass. .	Corn, . .	Oats, . .	Wheat, .	Grass.
Three, . . .	. . . . .	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat.
Four, . . .	. . . . .	. . . . .	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats.

Tier.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
One, ...	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat, .	Grass. .	Corn.
Two, ...	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat, .	Grass.
Three, . . .	Grass, .	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat.
Four, . . .	Wheat, .	Grass, .	Corn, . .	Oats, . .	Wheat, .	Grass, .	Corn, . .	Oats.

The valuable ingredients of plant food were furnished in the following forms:

Nitrogen.—Dried blood, nitrate of soda and sulphate of ammonia.

Available Phosphoric Acid.—Dissolved bone, ground bone and blood.

Potash.—Muriate of potash.

Prior to 1888 the amount of valuable ingredients applied per plot was computed on the guaranteed composition of the fertilizers, which in all cases were high grade goods purchased from reputable manufacturers. Since that time, analyses of the materials used have been made each year and the amount to be applied computed on the actual composition. These analyses have not shown a material variation from the seller's guarantee.

All fertilizers have been sown broadcast by hand after the land was plowed. The land was then thoroughly cultivated and prepared for seeding, excepting the barn yard manure, which has been spread and plowed under as in ordinary farm practice.

The preparation of the soil, manner and time of seeding, culture and time of harvesting have been made as nearly similar for all plots and for different years as has been possible.

The grass has been grown from a mixture of equal weights of clover and timothy seed, sown with wheat.

Results for 1895.

Corn.—Barn yard manure was applied to plots 16, 18, 20 and 22, April 13. Land plowed April 21–23d. Lime applied to plots 22 and 23 May 4th, and the commercial fertilizer applied broadcast on the plowed ground before the cultivators were used. The land was thoroughly pulverized with a spring tooth harrow May 4th. Planted to a Dent variety commonly grown in this locality in hills three feet apart each way, three grains in a hill, May 5th.

The corn came up very irregular. Wherever the underlying limestone rocks came within a few feet of the surface there was not enough moisture in the ground to allow the corn to germinate. After it came up it grew very rapidly. It was cultivated five times during the season. There was an average growth of stalks and the ears on most of the plots were well filled out. Harvested and put in small shocks Sept. 7–8. Husked and hauled to barn and weighed Oct. 1–6. Stover hauled in and weighed Oct. 30.

Oats.—All plots plowed seven to eight inches deep April 16–17. Land thoroughly pulverized with spring tooth and smoothing harrows April 17–18. April 18 seeded to Japan oats with a force feed drill, at the rate of two bushels per acre. Land rolled on the 20th. Up to June first the oats made a very poor growth. After this they made a very good growth. Oats harvested July 20–22, and put up in shocks on the 29th. Taken to the barn, weighed and threshed August 1st. The army worm done considerable damage in this vicinity, but did practically no damage on the fertilizer plots.

Wheat.—Yard manure was applied to plots 16, 18, 20 and 22, August 10, 1895. All plots plowed eight inches deep August 26–27th. Commercial fertilizers applied broadcast on the plowed ground before harrowing. After which the land was thoroughly pulverized September 3d. All plots seeded to Deitz Longberry Red wheat at the rate of two bushels per acre, with a force feed drill September 3d. A considerable amount of the wheat was winter killed, varying from 5 per cent. on the best plots to 75 per cent. on the worst plots; an average of about 25 per cent. for all the plots. The plots were cut and shocked July 6–7th and hauled to the barn, weighed and threshed July 13th.

Grass.—The grass seed was sown with the wheat, a mixture of two quarts of timothy and one quart of red clover, at the rate of 8 quarts

per acre. On April 9th, 1895, four quarts of clover seed was sown in addition to that sown the previous fall. Owing to the very dry weather the first crop made a very poor growth. It was cut June 29th, cured in the swath, and hauled to the barn and weighed on the 20th. The second crop or aftermath was cut August 17th and hauled to the barn and weighed on the 19th.

Yield per Acre of Different Plots—1896.

Number of plot.	Kind of Fertilizer Applied.	Quantity of Fertilizer Applied per Acre.		Quantity of Valuable Ingredients Applied per Acre.			Corn—Tier I.			Oats—Tier IV.			Wheat—Tier III.			Grass—Tier II.
		Corn.	Wheat.	Nitrogen.	Phosphoric acid.	Potash.	Ears per acre—70 lbs. per bushel.	Stover per acre.	Number of stalks per acre.	Grain per acre—32 lbs. per bushel.	Straw per acre.	Weight per bushel.	Grain per acre—60 lbs. per bushel.	Straw per acre.	Weight per bushel.	Hay per acre.
		Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Bus.	Lbs.	No.	Bus.	Lbs.	Lbs.	Bus.	Lbs.	Lbs.	Lbs.
1	Nothing,	.....	.....	.....	.....	.....	17.14	1,040	8,064	39.28	1,283	33.75	1.58	205	60.00	1,120
2	Dried blood,	261	187	24	.....	.....	46.86	1,640	8,992	41.44	1,474	34.63	1.88	207	60.00	1,580
3	Dissolved bone black,	277	293	.....	48	.....	[illegible]	[illegible]	[illegible]	51.78	1,703	33.75	11.85	1,009	60.13	1,540
4	Muriate of potash,	201	198	.....	.....	100	32.00	1,960	9,248	37.27	1,464	34.75	4.13	272	59.38	1,424
5	Dried blood,	261	187	24	48	.....	40.00	1,840	8,784	61.17	1,602	34.50	18.83	1,474	61.75	2,080
	Dissolved bone black,	277	293													
6	Dried blood,	261	187	24	.....	100	19.43	1,420	9,184	39.17	1,346	33.75	7.40	596	61.25	1,900
	Muriate of potash,	201	198													
7	Dissolved bone black,	277	293	.....	48	100	46.86	2,120	9,568	60.75	1,936	34.13	17.90	1,186	61.88	2,600
	Muriate of potash,	201	198													
8	Nothing,	.....	.....	.....	.....	.....	46.86	2,160	9,328	45.97	1,489	35.13	12.27	864	61.38	2,520
	Dissolved bone black,	277	293													
9	Muriate of potash,	201	198	24	48	100	43.43	2,120	9,528	61.31	2,038	34.13	22.90	1,626	63.13	3,384
	Dried blood,	261	187													
	Dissolved bone black,	277	293													
10	Muriate of potash,	201	198	48	48	100	46.86	2,280	9,216	60.14	1,996	33.63	22.88	1,607	61.13	3,448
	Dried blood,	523	374													
	Dissolved bone black,	277	293													
11	Muriate of potash,	201	198	72	48	100	45.71	2,200	9,056	60.02	2,200	33.88	24.78	1,765	62.13	3,760
	Dried blood,	784	560													
	Ground bone,	208	185													
12	Muriate of potash,	201	198	30	48	100	46.86	2,000	8,968	52.30	1,830	35.00	15.15	971	62.25	3,288
13	Dried blood,	243	180													
14	Plaster,	320	320	.....	.....	.....	24.00	1,080	8,688	33.16	1,179	34.25	8.07	556	61.38	1,636
	Nothing,	.....	.....	.....	.....	.....	36.57	1,600	8,744	30.36	948	33.63	6.73	396	61.25	1,688
15	Dissolved bone black,	277	293	.....	.....	.....	57.14	2,320	9,344	52.44	1,882	33.00	16.67	1,140	62.38	3,480
	Muriate of potash,	201	198	.....	48	100	45.71	1,920	8,216	48.10	1,681	33.00	19.83	1,370	62.50	3,040
16	Yard manure,	12,000	12,000	.....	.....	.....										
	Dissolved bone black,	277	293													
17	Muriate of potash,	201	198	24	48	100	42.29	1,930	8,424	49.77	1,728	34.00	22.17	1,670	61.88	2,788
	Dried blood,	261	187													

Yield per Acre of Different Plots—1896—Continued.

Number of plot.	Kind of Fertilizer Applied.	Quantity of Fertilizer Applied per Acre.		Quantity of Valuable Ingredients Applied per Acre.			Corn—Tier I.			Oats—Tier IV.			Wheat—Tier III.			Grass—Tier II.
		Corn.	Wheat.	Nitrogen.	Phosphoric acid.	Potash.	Ears per acre—70 lbs. per bushel.	Stover per acre.	Number of stalks per acre.	Grain per bushel—32 lbs. per bushel.	Straw per acre.	Weight per bushel.	Grain per acre—60 lbs. per bushel.	Straw per acre.	Weight per bushel.	Hay per acre.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Bus.	Lbs.	No.	Bus.	Lbs.	Lbs.	Bus.	Lbs.	Lbs.	Lbs.
18	Yard manure,	16,000	16,000	.....	.....	.....	42.29	1,840	8,712	50.81	1,786	34.13	22.50	1,650	62.25	3,104
19	Dissolved bone black,	277	293	48	48	100	43.43	2,040	9,144	54.24	1,864	34.75	23.23	1,606	61.88	3,020
	Muriate of potash,	201	198													
	Dried blood,	523	374													
20	Yard manure,	20,000	20,000	.....	.....	.....	48.00	2,000	8,952	53.81	1,878	35.13	21.28	1,323	62.75	2,840
21	Dissolved bone black,	277	293	72	48	100	45.71	2,000	8,872	53.78	2,199	35.25	22.50	1,610	62.63	2,704
	Muriate of potash,	201	198													
	Dried blood,	784	560													
22	Yard manure,	12,000	12,000	.....	.....	.....	56.00	2,200	8,912	54.77	2,032	33.00	20.70	1,238	62.75	2,016
23	Lime,	4,000	.....	.....	.....	.....	22.86	1,160	8,144	39.17	1,946	32.13	9.80	584	61.38	856
24	Lime,	4,000	.....	.....	.....	.....	17.14	800	6,520	41.33	1,358	34.75	6.37	378	61.75	924
25	Nothing,	277	293	.....	48	100	48.00	2,000	9,224	60.81	1,934	35.50	16.63	1,242	62.88	1,960
	Dissolved bone black,	201	198													
	Muriate of potash,	277	293													
26	Dissolved bone black,	201	198	24	48	100	43.43	1,760	8,392	62.11	2,052	33.25	23.30	1,402	63.63	2,224
	Muriate of potash,	158	167													
	Nitrate of soda,	277	293													
	Dissolved bone black,	201	198	48	48	100	48.00	2,000	8,744	60.38	2,108	35.38	21.55	1,427	63.25	2,440
27	Muriate of potash,	316	334													
	Nitrate of soda,	277	293													
	Dissolved bone black,	201	198	72	48	100	45.71	1,880	8,504	59.72	2,125	34.38	18.27	1,504	63.00	2,504
28	Muriate of potash,	474	501													
	Nitrate of soda,	277	293													
	Dissolved bone black,	201	198	.....	48	100	40.00	1,760	8,568	60.81	2,054	35.88	15.87	808	62.75	1,592
29	Muriate of potash,	277	293													
	Dissolved bone black,	201	198	24	48	100	37.71	1,640	7,872	60.03	2,023	36.38	22.17	1,470	62.88	2,208
	Muriate of potash,	119	121													
30	Sulphate of ammonia,	277	293													
	Dissolved bone black,	201	198	48	48	100	48.00	2,320	8,200	67.06	2,214	34.25	23.73	1,560	63.38	2,232
31	Muriate of potash,	237	241													
	Sulphate of ammonia,															

| | | |

Effect of Different Combinations and Different Amounts of Fertilizers—1896.

Number.	Kind of Fertilizer Applied.	Quantity of Single Ingredients per Acre.		Quantity of Valuable Ingredients per Acre.			Number of plot.	Corn—Tier I.			Oats—Tier IV.			Wheat—Tier III.			Grass—Tier II.
		Corn.	Wheat.	Nitrogen.	Phosphoric acid.	Potash.		Ears per acre—70 lbs. per bushel.	Stover per acre.	Number of stalks per acre.	Grain per acre—32 lbs. per bushel.	Straw per acre.	Weight per bushel.	Grain per acre—60 lbs. per bushel.	Straw per acre.	Weight per bushel.	Hay per acre.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Bus.	Lbs.	No.	Bus.	Lbs.	Lbs.	Bus.	Lbs.	Lbs.	Lbs.
1	Nothing,	.....	.....	.....	.....	.....	5	29.48	1,368	8,050	40.18	1,318	34.15	7.59	505	61.25	1,378
2	Dried blood,	261	187	24			1	46.86	1,640	8,992	41.44	1,474	34.63	1.88	207	60.00	1,580
3	Dissolved bone black,	277	293	.....	48	.....	1	42.29	1,960	8,856	51.78	1,703	33.75	11.85	1,009	60.13	1,540
4	Muriate of potash,	201	198	.....	.....	100	1	40.00	1,840	8,784	61.17	1,602	34.50	18.83	1,474	61.75	2,080
5	Dried blood,	261	187	24	48	.....	1	32.00	1,960	9,248	37.27	1,464	34.75	4.13	272	59.38	1,424
	Dissolved bone black,	277	293														
6	Dried blood,	261	187	24	.....	100	1	19.43	1,420	9,184	39.17	1,346	33.75	7.40	596	61.25	1,900
	Muriate of potash,	201	198														
7	Dissolved bone black,	277	293	.....	48	100	4	48.00	2,050	9,176	58.70	1,952	34.63	16.77	1,094	62.47	2,408
	Muriate of potash,	201	198														
8	Dissolved bone black,	277	293	24	48	100	2	42.86	2,025	8,976	55.54	1,883	34.07	22.54	1,648	62.51	3,086
	Muriate of potash,	201	198														
	Dried blood,	261	187														
9	Dissolved bone black,	277	293	48	48	100	2	45.15	2,160	9,180	57.19	1,930	34.19	23.06	1,607	61.51	3,234
	Muriate of potash,	201	198														
	Dried blood,	523	374														
10	Dissolved bone black,	277	293	72	48	100	2	45.71	2,200	8,964	56.90	2,200	34.57	23.64	1,688	62.38	3,232
	Muriate of potash,	201	198														
	Dried blood,	784	560														
11	Dissolved bone black,	277	293	24	48	100	1	43.43	1,760	8,392	62.11	2,052	33.25	23.30	1,402	63.63	2,224
	Muriate of potash,	201	198														
	Nitrate of soda,	158	167														
12	Dissolved bone black,	277	293	48	48	100	1	48.00	2,000	8,744	60.38	2,108	35.38	21.55	1,427	63.25	2,440
	Muriate of potash,	201	198														
	Nitrate of soda,	316	334														
13	Dissolved bone black,	277	293	72	48	100	1	45.71	1,880	8,504	59.72	2,125	34.38	18.27	1,504	63.00	2,504
	Muriate of potash,	201	198														
	Nitrate of soda,	474	501														
14	Dissolved bone black,	277	293	24	48	100	1	37.71	1,640	7,872	60.03	2,023	36.38	22.17	1,470	62.88	2,208
	Muriate of potash,	201	198														
	Sulphate of ammonia,	119	121														

15	Dissolved bone black, Muriate of potash, Sulphate of ammonia,	277 201 237	293 198 241	48	48	100	1	48.00	2,320	8,200	67.06	2,214	34.25	23.73	1,560	63.38	2,232
16	Dissolved bone, Muriate of potash, Sulphate of ammonia,	277 201 256	293 198 362	72	48	100	1	32.00	1,329	6,728	58.89	2,216	34.50	20.82	1,531	61.25	1,816
17	Yard manure,	12,000	12,000				1	45.71	1,920	8,216	48.10	1,681	33.00	19.83	1,370	62.50	3,040
18	Yard manure,	16,000	16,000				1	42.29	1,840	8,712	50.81	1,786	34.13	22.50	1,650	62.25	3,104
19	Yard manure,	20,000	20,000				1	48.00	2,000	8,952	53.31	1,878	35.13	21.28	1,323	62.75	2,840
20	Yard manure, Lime,	12,000 4,000	12,000				1	56.00	2,200	8,912	54.77	2,032	32.00	20.70	1,238	62.75	2,016
21	Lime,	4,000					1	22.86	1,160	8,144	39.17	1,946	32.13	9.80	584	61.38	856
22	Ground limestone,	4,000	4,000				1	33.14	1,480	7,888	58.10	1,721	32.25	15.03	858	63.13	784
23	Plaster,	320	320				2	20.00	1,000	7,792	41.72	1,416	33.44	10.00	681	61.76	1,258
24	Ground bone, Muriate of potash, Dried blood,	208 201 243	185 198 180	30	48	100	2	46.29	2,020	8,692	57.03	2,047	35.32	15.87	1,008	62.69	2,534
	Average yield of plots receiving complete fertilizers containing—																
	Dried blood,						6	44.57	2,095	8,707	56.54	2,004	34.27	23.08	1,647	62.13	3,186
	Nitrate of soda,						3	45.71	1,880	8,547	60.07	2,095	34.34	21.04	1,444	63.29	2,389
	Sulphate of ammonia,						3	39.24	1,760	7,600	61.99	2,151	35.04	22.24	1,520	62.50	2,085
	Nitrogen, 24 lbs. per acre,						4	41.72	1,863	8,554	58.31	1,960	34.44	22.64	1,542	62.88	2,651
	Nitrogen, 48 lbs. per acre,						4	46.57	2,160	8,826	60.71	1,546	34.50	22.85	1,550	62.41	2,795
	Nitrogen, 72 lbs. per acre,						4	42.28	1,850	8,290	58.10	2,185	34.50	2,159	1,603	62.25	2,696
	Yard manure,						4	48.00	1,990	8,698	51.87	1,844	33.82	21.08	1,395	62.56	2,750

RELATIVE STAND AND YIELD OF GRASS ON THE PLOTS IN THE GENERAL FERTILIZER EXPERIMENTS.

By ENOS H. HESS.

Noticing the large difference there was in the stand of clover and timothy on the different plots it was scored several times in order to see what comparative effect the different fertilizers had on clover and timothy. The plot having the best stand of either clover or timothy was scored at 100 and the other plots in proportion as the stand decreased. In the relative yield the plot yielding the largest amount of hay was second at 100 and the others in proportion. This was taken from the actual weights and therefore is accurate. The stand had to be estimated, but as it was repeated several times by different persons it represents fairly well the truth of the matter. In 1896 the amount of sorrell on each plot was estimated, the one having the largest amount of it was scored at 100. There was a large amount of it in this section of the State, but, as will be seen by the table, the amount is influenced very materially by the kind of fertilizer used.

1895.—Plots scored April 26th and May 3d, by two persons and May 10th by one person.

1896.—Plots scored April 25th, May 2d, 8th, 15th, and 22d, on stand of clover and timothy. On May 15th and 22d the amount of sorrel was also estimated.

Relative Stand and Yield of Grass.

Number.	Kind of Fertilizer Applied.	Approximate amount applied to the corn and wheat.	Quantity of Valuable Ingredients per Acre.			Number of plots.	1895.				1896.					Average 1895-96.			
			Nitrogen.	Phosphoric acid.	Potash.		Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay, assuming No. 12 to be 100.	Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay, assuming No. 9 to be 100.	Amount of sorrel.	Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay.
1	Nothing,	.....	.....	.....	.....	5	32	46	39.0	36.3	16	59	37.8	42.6	17	24	53	38.4	39.5
2	Dried blood,	200	24	.....	.....	1	22	27	24.5	26.0	3	61	34.7	48.9	1	15	44	29.6	37.5
3	Dissolved bone black,	250	.....	48	.....	1	31	71	51.0	30.0	26	83	54.3	47.6	20	29	77	52.7	38.8
4	Muriate of potash,	200	.....	.....	100	1	50	45	47.5	43.2	15	49	31.8	44.0	5	33	47	39.7	43.6
5	**Dried blood,**	200	24	48	.....	1	14	86	50.0	35.6	50	85	67.3	64.3	38	32	86	58.7	50.0
	Dissolved bone black,	250																	
	Dried blood,	200	24	.....	100	1	22	17	19.5	26.0	16	69	42.3	58.8	4	19	43	30.9	42.4
6	Muriate of potash,	200																	
	Dissolved bone black,	250																	
7	**Muriate of potash,**	200	.....	48	100	4	87	83	85.0	86.2	69	82	76.3	74.5	18	78	83	80.7	80.4
	Dissolved bone black,	250																	
	Muriate of potash,	200	24	48	100	2	61	85	73.0	78.0	94	93	93.2	95.4	38	78	89	83.1	86.7
8	Dried blood,	200																	
	Dissolved bone black,	250																	
	Muriate of potash,	200	48	48	100	2	70	88	79.0	69.3	88	94	89.9	100.0	73	79	91	84.5	84.7
9	Dried blood,	400																	
	Dissolved bone black,	250																	
	Muriate of potash,	300	72	48	100	2	51	91	71.0	75.4	81	97	88.7	99.9	73	66	84	79.9	87.7
10	**Dried blood,**	600																	
	Dissolved bone black,	250																	
	Muriate of potash,	200	24	48	100	1	72	87	79.5	96.0	74	77	76.5	68.8	48	73	82	78.0	82.4
11	Nitrate of soda,	175																	
	Dissolved bone black,	250																	
	Muriate of potash,	200	48	48	100	1	71	84	77.0	100.0	75	83	78.9	75.6	67	73	84	78.0	87.8
12	Nitrate of soda,	350																	
	Dissolved bone black,	250																	
	Muriate of potash,	200	72	48	100	1	63	89	76.0	90.6	74	81	77.6	77.4	100	69	85	76.8	84.0
13	Nitrate of soda,	425																	
	Dissolved bone black,	250																	
	Muriate of potash,	200	24	48	100	1	61	82	71.5	75.1	82	81	81.3	68.3	25	72	82	76.4	71.7
14	**Sulphate of ammonia,**	125																	

Relative Stand and Yield of Grass—Continued.

Number.	Kind of Fertilizer Applied.	Approximate amount applied to the corn and wheat.	Quantity of Valuable Ingredients per Acre.			Number of plots.	1895.				1896.					Average 1895-96.			
			Nitrogen.	Phosphoric acid.	Potash.		Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay, assuming No. 12 to be 100.	Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay, assuming No. 9 to be 100.	Amount of sorrel.	Stand of clover.	Stand of timothy.	Average of clover and timothy.	Relative weight of hay.
15	Dissolved bone black, 250 Muriate of potash, 200 Sulphate of ammonia, 250		48	48	100	1	29	83	56.0	45.9	76	88	81.9	69.0	75	53	86	69.0	57.5
16	Dissolved bone black, 250 Muriate of potash, 200 Sulphate of ammonia, 375		72	48	100	1	8	86	47.0	33.8	66	93	79.5	56.2	78	37	90	63.3	45.0
17	Yard manure,	12,000	.....	.....	.....	1	80	79	69.5	82.8	78	91	82.3	94.0	43	79	85	75.9	88.4
18	Yard manure,	16,000	.....	.....	.....	1	68	79	73.5	83.5	69	95	81.8	96.0	73	69	87	77.7	89.8
19	Yard manure,	20,000	.....	.....	.....	1	85	76	81.0	93.0	82	91	86.3	87.8	83	84	84	83.7	90.4
20	Yard manure,	12,000																	
	Lime,†	4,000	.....	.....	.....	1	91	76	83.5	88.8	45	83	64.0	62.3	5	68	80	73.8	75.6
21	Lime,†	4,000	.....	.....	.....	1	13	58	35.5	34.0	4	61	32.5	26.5	3	9	60	34.0	30.3
22	Ground limestone,	4,000	.....	.....	.....	1	51	49	50.0	53.6	5	51	28.0	24.2	.....	28	50	39.0	38.9
23	Plaster,	320	.....	.....	.....	2	38	38	38.0	33.6	11	65	37.5	38.9	29	25	52	37.8	36.3
24	Ground bone, 200 Muriate of potash, 200 Dried blood, 200		30	48	100	2	91	91	91.0	90.7	91	91	90.9	78.4	33	91	91	91.0	84.6
	Average of plots receiving complete feltilizers containing—																		
	Dried blood,	.....	.....	.....	.....	6	61	88	74.2	74.2	87	95	90.6	98.4	61	74	92	82.4	86.3
	Nitrate of soda,	.....	.....	.....	.....	3	69	87	77.5	95.5	74	80	77.7	73.9	72	72	84	77.6	84.7
	Sulphate of ammonia,	.....	.....	.....	.....	3	33	84	58.2	51.6	75	87	80.9	64.5	59	54	86	69.6	58.1
	Nitrogen, 24 pounds per acre	.....	.....	.....	.....	4	64	85	74.3	81.8	86	86	86.1	77.5	37	75	86	80.2	79.7
	Nitrogen, 48 pounds per acre	.....	.....	.....	.....	4	60	86	72.7	71.2	82	90	85.2	81.5	72	71	88	79.0	76.4
	Nitrogen, 72 pounds per acre,	.....	.....	.....	.....	4	43	89	66.0	68.8	75	92	83.6	77.8	81	59	91	74.8	73.3
	Yard manure,	.....	.....	.....	.....	4	81	78	79.4	87.0	69	90	78.6	85.0	51	75	84	79.0	86.0

†The lime is applied to the corn only.

Discussion.

1895.—The figures showing the relative stand do not agree exactly with the actual amount of hay secured from each plot. But in most cases it is as close as could be expected. The largest difference exists in Nos. 3, 5, 11, 12, 13, 16, 17 and 19. This can be accounted for in some cases by the effect of the weather. The plots receiving nitrate of soda as a source of nitrogen were scored considerably lower than their yield, while two of the plots receiving sulphate of ammonia scored higher than the actual yield. Up to the middle of June the season was very dry. This corroborates the theory that nitrate of soda is best in a dry season and sulphate of ammonia best in a wet one. The conditions of the weather in May and June was such that nitrate of soda worked at an advantage and sulphate of ammonia at a disadvantage. The stand of timothy on the sulphate of ammonia plots was very good in April, but it appeared to burn up as the hot weather came on. It was the opposite with the nitrate of soda plots.

It will be noted that as the amount of nitrogen applied increases the stand of clover decreases and the timothy increases. The stand of clover being 64, 60 and 43, where 24, 48 and 72 pounds of nitrogen respectively was applied. The stand of timothy on these plots was 85, 86 and 89 respectively. Each of these scores are the average of four plots. The largest difference in the stand of clover will be found on the plots receiving their nitrogen in the form of sulphate of ammonia; it being 61, 29 and 8 on the plots receiving 24, 48 and 72 pounds of nitrogen, respectively, per acre. This would indicate that the clover plant is not benefited by the application of nitrogen to the soil, at least when applied in too large quantities. The timothy, however, shows the opposite effect. It may be that the timothy got a better start on the plots receiving the large quantities of nitrogen and, to a certain extent, crowded the clover out.

1896.—This was a dry season up to June first and as will be observed the yield of the plots receiving sulphate of ammonia was less than the relative stand, while the plots receiving dried blood as a source of nitrogen produced considerable more hay than the stand would of indicated in the spring. The figures for the other plots although not agreeing exactly, agree as a whole very well. Again, as in 1895 the stand of clover is decreased as the amount of nitrogen applied is increased while the stand of timothy increases as the nitrogen applied is increased; but not in the same proportion. The plots receiving yard manure produced more hay than the stand indicated. This may have been due to humus, supplied by the manure, retaining more moisture during the dry season than the other plots receiving commercial fertilizers.

Average. — The average results for the two years give more reliable data than that of one year. It should be rememberd that these plots have been receiving the same treatment for the past fourteen years. The marked differences now observed would not have existed in the former part of the experiment. We must expect the difference on the different plots to become more marked as the experiment continues and shall be reported from time to time.

VARIETY TESTS.

BY ENOS H. HESS.

Wheat.

"The comparison of new and standard varieties of wheat begun by the State College Agricultural Experiment Station in 1890 has been continued through the present season. They were grown under as nearly similar conditions of soil, exposure, fertilizer, drainage, culture, etc., as possible, and the yields reported below are from careful weighing of the product of the different plots made at the time of threshing.

The plots were one-thirtieth acre in size. The land was plowed August 27th to the depth of seven or eight inches, thoroughly pulverized and firmed. The rotation followed is wheat, grass, potatoes and oats.

Two hundred pounds dissolved bone black, containing 16.37 per cent. phosphoric acid, was applied per acre at the time of seeding and twenty tons of yard manure before the land was plowed. All the varieties were sown at the rate of six pecks per acre.

Yield of Wheat Varieties for 1896 and the Average for 7 years 1890-1896.

	Name of Variety.	1896.			1890-1896, Average 7 years.				
		Grain yield per acre.	Straw per acre.	Weight per struck bushel.	Grain yield per acre.	Straw yield per acre.	Weight per struck bushel.	Bearded, smooth or amber.	Color of grain, red, amber or white.
		Bus. (60 lbs)	Lbs.	Lbs.	Bus. (60 lbs)	Lbs.	Lbs.		
1	Reliable,	23.95	862	64.50	32.21	3,797	62.83	B	R
2	Fulcaster,	29.81	1,803	64.13	30.75	4,047	62.80	B	R
3	Ontario Wonder,	30.57	1,543	62.25	30.22	3,245	61.43	S	R
4	Valley,	25.14	1,509	63.75	29.89	4,020	62.57	B	R
5	Wyandotte Red,	27.99	1,410	63.38	29.82	3,107	63.39	S	R
6	Currell's Prolific,	27.56	1,656	63.38	29.66	3,398	62.80	S	R
7	Derby Longberry Red,	24.61	1,613	64.13	29.31	3,734	62.78	B	R
8	Mediterranean,	27.57	1,650	63.50	28.10	3,726	62.67	B	R
9	German Emperor,	26.46	2,004	62.75	27.98	3,295	62.16	S	R
10	Red Fultz,	26.52	1,282	62.88	27.97	3,516	61.77	S	R
11	Finley,	24.63	1,252	63.50	27.93	2,995	62.56	S	R
12	Fultz,	21.58	1,148	63.75	27.85	3,066	63.01	S	R
13	Mealy,	22.93	1,095	63.25	27.83	3,031	60.14	S	R
14	Theiss,	22.12	1,144	63.63	27.63	3,393	61.82	B	R
15	Extra Early Oakly,	19.97	1,043	63.63	27.36	3,075	62.57	S	R
16	Democrat,	19.61	1,266	63.38	27.34	3,455	62.61	B	A
					1893-1896 Average 4 years.				
17	Royal Australian,	27.75	1,496	62.13	30.56	3,197	61.64	S	W
18	Canada Wonder,	25.59	1,625	63.75	29.60	3,327	63.52	B	R
19	Jones' Square Head	26.97	1,543	61.63	29.11	2,953	60.30	S	W
20	The Pool,	24.43	977	63.13	28.51	2,928	63.02	S	R
21	American Bronze,	22.92	1,636	61.63	27.88	2,994	62.42	S	A
22	Rudy	25.92	1,318	62.25	27.81	3,020	62.08	B	R
23	Jones' Winter Fife,	19.97	1,043	63.50	27.16	3,080	61.41	S	R
					1894-1896 Average 3 years.				
24	Miama Valley,	20.71	1,631	63.13	27.39	2,912	62.23	B	R
25	Oregon,	23.26	1,478	64.52	27.24	2,722	62.00	S	A
26	Egyptian,	19.66	1,291	63.88	26.97	3,023	62.63	S	R
27	Witter,	17.36	1,027	64.00	25.22	2,917	62.67	S	R

28	Forty Fold,	24.43	1,232	62.13				S	W
29	Reliable Minnesota,	22.78	1,363	62.13				B	A
30	Rochester Red,	21.85	1,419	61.63				S	A
31	Golden Cross,	11.52	1,022	58.44				B	R
	Average of 31 varieties,	23.74	1,369	62.95					
	Average of 27 varieties,				28.49	3,258	62.29		
	Average of 12 bearded varieties,	24.58	1,401	62.14					
	Average of 10 bearded varieties,				29.06	3,543	62.59		
	Average of 19 smooth varieties,	24.03	1,349	62.83					
	Average of 17 smooth varieties,				28.19	3,091	62.11		

Sixteen of the varieties have been grown side by side for the past seven years. Seven have been under trial for four consecutive years, four for three years and four for one year.

About 10 per cent. of all the varieties were winter killed. There was very little difference in the amount of the different varieties killed with the exception of the Golden Cross which had about 40 per cent. winter killed and the Reliable which had about 25 per cent. winter killed. The Reliable was sown at the north-west end of the field so that the large amount winter killed was probably due as much to the position of the plot as to the variety itself.

In 1896 the Ontario Wonder, a smooth amber wheat, produced 30.57 bushels per acre, the largest yield of any variety tested. Following this variety in the order of their production are: Fulcaster, 29.81; Wyandotte Red, 27.99; Royal Australian, 27.75; Mediterranean, 27.57; Curell's Prolific, 27.56; Jones' Square Head, 26.97; Red Fulty, 26.52, and German Emperor, 26.46 bushels.

A far safer measure of the varieties tested will be found in the column showing the average yield for all the years tested. For the varieties tested seven years the average yield of the first six is as follows: Reliable, 32.21; Fulcaster, 30.75; Ontario Wonder, 30.22; Valley, 29.89; Wyandotte Red, 29.82, and Currell's Prolific, 29.66 bushels. For those tested four years the yield of the first three is as follows: Royal Australian, 30.56, Canada Wonder, 29.60, and Jone's Square Head, 29.11 bushels. It will be noted that the order of yield for 1896 varies considerably from that of all the years in which the varieties were tested, proving that the results obtained from a single year's trial is not an accurate test of the value of a variety but that it should be continued through at least two or three years in order that the test be of any material value.

Oats.

Eighteen varieties of oats were tested this season. The growth in the forepart of the season was poor. After June 1st they grew very rapidly and headed out well. The straw was so rank that a large part of it lodged. Ten days before the oats were ripe the army worm came into the field and destroyed a large part of the crop. From one-third to two-thirds of the grain was cut off by the worms. The amount destroyed on the different plots varied very materially. It destroyed the value of the test and the yield obtained from the different varieties would be very misleading and are therefore not reported.

Potatoes.

The comparison of new and standard varieties of potatoes begun by the Experiment Station in 1889 has been continued through the

present season. They were grown under as nearly similar conditions of soil, exposure, fertilizer, drainage, culture, etc., as possible, and the yields reported below are from careful weighing of the product of the different plots made at the time of digging. The rotation of crops on the ground used is wheat, grass, potatoes and oats. Barnyard manure at the rate of 18 tons per acre was applied to the sod before plowing. The land was plowed 7-8 inches deep and thoroughly pulverized with spring and spike tooth harrows. Large tubers were cut to one eye, medium sized to two and three eyes, and the smallest ones in two and three pieces. No tubers were used that did not weigh one and three-quarter ounces or over. The pieces were dropped 11 to 12 inches apart in rows 3 feet apart and covered about 3 inches deep. Shallow cultivation was practiced, a small amount of earth being thrown up to the stalks after the last cultivation.

The varieties were planted May 5th to 6th. All of them made a very rank growth of tops with the exception of the Early Puritan which made only a medium growth. They were sprayed with Paris green, on July 1st and 14th, to kill the Colorado potato beetle which was quite numerous in some sections of the field. All the varieties blossomed more freely than usual, some of them forming seed pods. They were dug August 27th and September 2d. The seed used was practically free from scab but no solution was used to kill it. For the proportion of the crop that was scabby see table.

The following varieties were either bought or received for trial: Northern Maine, Oliver Glover, Buffalo Cross Roads, Pa.; Maggie Murphy, The Storrs & Harrison Co., Painsville, O.; Great Divide, W. Atlee Burpee & Co., Philadelphia, Pa.; Enormous, A. E. Manurn, Bristol, Vt.; Victor Rose, James McCauley, Mifflintown, Pa.; Early May, Engene Hickok, Rose, N. Y.; Uncle Sam and 241-3, Peter Henderson & Co., New York, N. Y.; Carman No. 3, Joseph Breck & Sons, Boston, Mass.

11—22—96

Yield of Varieties of Potatoes for 1896.

Number.	Name of Variety.	Total yield per A.	Merchantable tubers per A. 1¾ oz. and over.	Unmerchantable tubers per A.	Per cent. of merchantable tubers.	Date of ripening.	Per cent. of tubers scabby.	Rough, smooth or medium.	Large, small or medium.
		Bush. (56 lb.)	Bush.	Bush.					
1	Enormous,	480.8	475.4	5.4	98.90	Aug. 25,	20	S	L
2	Northern Maine,	410.0	392.8	17.2	95.81	Sept. 2,	40	M	M
3	Delaware,	384.5	369.3	15.2	96.07	Sept. 2,	25	M	L
4	Early May,	375.4	347.4	28.0	92.50	Aug. 14,	10	M	M
5	Late Puritan,	367.3	359.0	8.3	97.74	Sept. 2,	45	S	M
6	Ben Harrison,	363.8	348.8	15.0	95.88	Sept. 2,	97	R	L
7	New Bovee Seedling,	353.1	332.1	21.0	94.06	Aug. 14,	10	S	M
8	New Queen,	348.9	326.8	22.1	93.68	Sept. 2,	25	S	L
9	Rose of Erin,	343.2	339.4	3.8	98.79	Aug. 25,	10	S	L
10	Maggie Murphy,	334.8	324.8	10.0	97.04	Aug. 25,	.....	S	L
11	Carman No. 1,	332.9	325.3	7.6	97.73	Sept. 2,	25	M	L
12	Freeman,	331.9	310.9	21.0	93.68	Aug. 25,	75	S	M
13	Victor Rose,	328.5	297.3	31.2	90.47	Aug. 14,	10	M	M
14	Early Everett,	311.6	288.4	23.2	94.10	Sept. 2,	60	M	M
15	Pennsylvania Best,	311.5	291.2	20.3	93.47	Sept. 2,	80	M	M
16	Early A,	308.4	289.8	18.6	93.97	Sept. 2,	85	M	M
17	Iron Daisy,	299.7	283.3	16.4	94.55	Sept. 2,	40	S	M
18	Brownell's Winner,	288.1	274.4	13.7	95.32	Sept. 2,	40	S	M
19	Burpee's Surprise,	279.8	264.9	14.9	94.69	Sept. 2,	50	S	M
20	Great Divide,	279.2	268.2	11.0	96.00	Sept. 2,	25	M	M
21	Stoneroad No. 1,	266.9	257.6	9.3	96.47	Sept. 2,	80	M	M
22	Stoneroad No. 2,	262.3	242.3	20.0	92.37	Sept. 2,	90	M	L
23	Early Maine,	257.3	229.3	28.0	89.12	Aug. 25,	85	M	M
24	Early Ohio,	235.1	222.4	12.7	94.64	Sept. 2,	80	M	M
25	Uncle Sam,	232.5	226.6	5.9	97.33	Sept. 2,	20	S	M
26	Rural New Yorker No. 2,	231.9	219.8	12.1	94.81	Sept. 2,	75	S	M
27	Green Mountain,	221.3	214.9	6.4	97.08	Sept. 2,	90	M	L
28	241 — 3	198.9	179.2	19.7	90.00	Aug. 14,	10	M	M
29	Carman No. 3,	176.7	173.9	2.8	98.43	Sept. 2,	50	S	L
30	Early Puritan,	146.3	134.5	11.8	91.96	Aug. 25,	30	S	S

Yield of Varieties for Three Years 1894-1896.

Number.	Name of Variety.	Total yield per A.	Merchantable tubers per A. 1¾ oz. and over.	Unmerchantable tubers per A.	Per cent. of merchantable tubers.
		Bush. (56 lbs.)			
1	Early Everett,	267.3	236.3	31.0	88.40
2	New Queen,	262.3	233.9	25.1	89.18
3	Ben Harrison,	259.9	237.7	22.3	91.50
4	Freeman,	256.9	224.8	32.2	87.50
5	Pennsylvania Best,	254.3	224.7	29.6	88.36
6	Early A,	253.7	228.9	24.8	90.22
7	Early Maine,	236.9	205.7	31.2	86.83
8	Stoneroad No. 2,	233.8	207.7	26.1	88.84
9	Rural New Yorker No. 2,	218.3	201.6	16.7	92.35
10	Stoneroad No. 1,	217.1	199.7	17.4	91.99
11	Burpee's Surprise,	203.4	180.5	22.9	88.74
12	Early Ohio,	193.6	173.2	20.4	89.46
13	Green Mountain,	190.2	175.3	14.9	92.17
14	Early Puritan,	148.5	130.3	18.3	87.74
	Average yield for two years, 1895-1896.				
1	New Bovee Seedling,	378.4	356.0	22.4	94.08
2	Carman No. 1,	327.7	312.2	15.6	95.27
3	Delaware,	323.3	305.8	17.5	94.59
4	Late Puritan,	322.6	306.6	16.0	95.04
5	Rose of Erin,	303.8	296.2	7.6	97.50
6	Brownell's Winner,	293.1	277.2	15.9	94.58
7	Irish Daisy,	276.9	255.0	22.4	92.09
	Yield for 1 year, 1896.				
1	Enormous,	480.8	475.4	5.4	98.90
2	Northern Maine,	410.0	392.8	17.2	95.81
3	Early May,	375.4	347.4	28.0	92.50
4	Maggie Murphy,	334.8	324.8	10.0	97.04
5	Victor Rose,	328.5	297.3	31.2	90.47
6	Great Divide,	279.2	268.2	11.0	96.00
7	Uncle Sam,	232.5	226.6	5.9	97.33
8	241/3	198.9	179.2	19.7	90.00
9	Carman No. 3,	176.7	173.9	2.8	98.43

It will be noted that for 1896 the Enormous gives considerably the largest yield (480.80) of any variety tested. Following this variety in the order of their production are: Northern Maine, 410.0; Delaware, 384.5; Early May, 375.4; Late Puritan, 367.3; Ben Harrison, 363.8; and New Bovee Seedling, 353.1 bushels per acre. This was a very good year for the growth of potatoes and makes a very favorable showing for the new varieties received this year. For the other varieties a far safer measure of their value is found in the average yield for all the years tested. The first six varieties tested three years stand as follows: Early Everett, 267.3; New Queen, 262.3; Ben Harrison, 259.9; Freeman, 256.9; Pennsylvania Best, 254.3; and Early A., 253.7 bushels per acre. In the list tested two years they stand as follows: New Bovee Seedling, 378.4; Carman No. 1, 327.7; Delaware, 323.3 bushels per acre.

THE ARMY WORM.

By B. H. WARREN, M. D., State Zoologist.

During last summer this insect made its appearance in large numbers in numerous counties where a great amount of damage was done to different crops as will be seen by the accompanying reports from various sections of the State. The writer is indebted to Prof. Chas. W. Johnson, Entomologist Wagner Free Institute of Science, of Philadelphia, for the following description, with its life habits, history, parasites, etc. The paper I originally prepared for this report was unfortunately destroyed in the fire which consumed all my library as well as note books.

THE ADULT OR MOTH.

This destructive insect has been thoroughly studied and described by our able economic entomologists,* but many of their writings are perhaps inaccessible to the larger number of our agriculturists and it is for this reason that the following description, with its life habits, history, etc., is written:

The moth or adult is a plain dull colored insect, a little less than an inch in length, but with wings expanded nearly an inch and three-quarters. The fore-wing is a dull reddish or grayish brown, speckled with minute black dots, most of which are arranged in two transverse rows near the outer portion of the wing. Near the center of the wing is a small white spot, a characteristic marking from which the insect derives its specific name, unipuncta, near this spot on either side towards the anterior portion, are two yellowish round spots, each with a somewhat clouded center; around the white spot is also a more or less clouded appearance, and near the tip of the wing is a dusky oblique streak. The veins on the posterior portion of the wing are marked by fine white lines. The hind wing is a gray smoky color, darker towards the outer edge, with blackish veins, both wings are light gray beneath and do not show any of the markings of the upper side.

*Fitch, Sixth Report on the noxious insects of the State of New York, Riley, Eighth Missouri Report, and the Report of the Department of Agriculture, Washington, 1881 and 1882; Packard, Report on the Rocky Mountain Locust and other insects, etc. (Ninth Annual Report of the U. S. Geological and Geographical Survey of the Territories); Walsh, Insects Injurious to the Vegetation of Illinois; Comstock, Report of the Department of Agriculture, Washington, 1879, Smith, Economic Entomology.

Army Worm—(*Leucania unipuncta.*)

Calosoma Calidum.

THE EGGS.

The egg when first laid is spherical, .02 inch in diameter, smooth, opaque white, covered with a glistening, adhesive fluid; shell delicate, becoming faintly iridescent and more sordid before hatching, The larvae when first hatched, is 1.7 millimeters in length, dull white and a large dark head. In the first and second stages, the two front pairs of abdominal legs are atrophied so as to necessitate a loping gait. In the third stage the loping habit is lost, but the front abdominal legs are still somewhat the smallest. In the fourth stage, the color is dull, dark green and the chameleonitic brown lines appear—(Riley).

THE LARVAE.

The matured larvae is about an inch and a half long. Its cylindrical body, divided into thirteen rings, becomes more contracted and wrinkled at each end, and is sparsely covered with short hairs, The head is covered by a network of confluent spots, while along the middle of the face run two lines diverging at each end. A light colored, waved line, just above the legs, is succeeded by a dark one; then a light one, edged with two thread-like lines; while the upper part is dark, with an interrupted white thread running exactly through the middle of the back.

The forelegs, ten in number, are marked on their outer middle and on their tip with black. Beneath the caterpillar is of livid green.

The pupa or chrysalis is dark brown in color, and is from 18 to 20 mm. (three-quarters of an inch) in length.

ITS LIFE, HABITS AND HISTORY.

Concerning the hibernation of the army worm, writers have long differed. We can now safely state that it hibernates both in the moth and chrysalis states, the former being more common in the southern part of the country, the later in the northern regions.—(Comstock). Moths are found in early spring in such fresh condition, with wings so soft that they have evidently just emerged from their pupal cases, and chrysalis have been found in the early spring from which the true army worm moth has emerged. The moth is also frequently found throughout the winter. Mr. Strecker found it hibernating in February at Reading. Mr. Riley has observed the female laying her eggs early in April, at St. Louis, Mo. It probably commences to oviposit in the southern portion of Pennsylvania early in May, while in the northern and more elevated sections a week or two later, governed, of course, by climatic conditions.

The moth deposits her eggs in the folded blades of grass or grain, always concealing them from sight by pushing them down into the unfolded portion of the leaf or by cementing the edges of the leaf

together over them. Sometimes, however, they are laid in a partial fold and remain perfectly exposed to view. The eggs are laid singly or in rows, which sometimes contain as many as fifteen or twenty. A single female produces from 500 to 700 eggs. During the larval or worm stage, which lasts from fifteen to thirty days, the worm casts its skin five times.

When migrating from an eaten field to fresh pastures, they have the peculiar habit of marching together, in one direction, in long columns, side by side, hence the popular name "Army Worm." Their food plants are naturally the grasses and grains, when on the march they attack, preferably, the cereals, timothy, blue grass and corn. Many other plants are eaten to a small extent. All insects in the larval stage are exceedingly voracious and eat surprising quantities of food. When these army worms are shut up together, without food, they will quickly devour each other. "The natural habitat of the army worm was stated by Dr. Fitch, to be in the wild grass of wet spots, in swamps and on the border of marshes, and in this statement he has been followed by nearly all succeeding writers. The question then, naturally arises, what is the cause of these sudden and extensive periodical visitations to cultivated crops? Dr. Fitch observed that the year 1861 was very wet, while that of 1860 had been extremely dry. On examining the records he found that in previous worm years the season in which the worms appeared was wet, while the preceding year was dry. He therefore proposed the theory that in a dry season this insect, having unlimited extent of feeding range, became greatly multiplied, and when it is thus multiplied, a wet season and over-flowed swamps drive it out from its lurking place, in flocks, alighting here and there over the country. But on being thus rusticated, it finds our arable lands too dry for it, and immediately on maturing and getting its wings again it flies back to the swamps, whereby it happens that we see no more of it. Professor Riley adopted this theory and showed that the conditions in 1869 and 1875 (two marked army worms years), coincided with those mentioned by Fitch."—(Comstock).

Can the above be applicable to the present case? During the summers of 1894 and 1895 there was a limited amount of rain. But has the rainfall been any greater this year, 1896, in the sections infested by the army worm?

ITS PAST HISTORY.

As to the past history of the army worm, it has been known in this country since 1743. It is impossible to say whether it is an indigene or whether it has been introduced from Europe. It was not until 1855 that the first step towards ascertaining definitely its life his-

tory was made. In that year John Kirkpatrick reared the perfect moth from the destructive worm, and described both pupa and adult in the Ohio Agricultural Report of the same year. More extensive studies were made, however, during the great army worm year of 1861 by Walsh, Kirkpatrick, Thomas Fitch, Packard and others. To Walsh and Kirkpatrick we are particularly indebted for a study of its parasites.

Dr. Fitch has shown that "worms in armies" and "black worms" referred to by writers as occurring in New York and New England, in 1743, 1770, 1790 and 1817, with habits like those of the army worm of 1861, must be the same species. In southern Illinois, in 1818 or 1820, they were more numerous than in 1861. They also made their appearance in greater or less numbers in 1825, 1826, 1834, 1841, 1842, 1849, 1856. In 1855 it appeared in northern Ohio. In 1854, 1865, 1866 and 1869 it abounded in portions of Missouri. In 1871 it occurred in Illinois, and in 1872 in Iowa and Wisconsin, Ohio, Kentucky, Illinois, Missouri and Tioga county, New York.

The year 1875 was another army worm year, and it abounded all over the country, especially in Missouri, Illinois, Delaware, Ohio, Kentucky, Iowa, New York, and throughout New England and in western New Brunswick—(Riley).

PARASITES AND PREDACEOUS INSECTS.

Perhaps the most important parasite is a dipterous insect belonging to the family Tachinidae. This fly was described by Kirkpatrick as Exorista leucaniae and by Walsh as Senometopia militaris. It is now known as Carcelia leucaniae—(Kirk). It is a common and widely distributed species, being found throughout the United States and Canada. To the casual observer it would resemble the common horse fly, but it is usually larger and more variable in size (.25 to .35 of an inch in length). The face is silvery, with lateral hairs. Front with a central black stripe and lateral black convergent hairs. Thorax bluish gray, with four longitudinal black stripes and black hair and bristles. Abdomen black or black with reddish and grayish lateral markings and covered with black hairs and bristles. It flies low in sunny places in the woods, with a loud buzzing noise.

"The eggs are much the shape and color of those of the flesh fly. The fly fastens its eggs by an insoluble cement on the upper surface of the two or three first rings of the body. Instinct appears to teach the mother fly that if she places her eggs further back, the little magots, as they hatch out and begin to penetrate the flesh will be felt by the victim and seized by its powerful jaws."—(Walsh).

"Mr. Walsh had fifty or sixty worms, of which all but two had eggs, from one to six in number fastened on the upper side. From

these he bred fifty-four Iachinids and two moths. Now these army worms averaged about three eggs apiece, and consequently two-thirds of the eggs of the Iachinids must have perished without arriving at maturity."

Another Iachinid (Frontina flavicauda, Riley), has similar habits to the above. Walsh describes three parasitic hymenopterous insects, Mesochorus vitreus, Pezoniachus minimus and Microgaster militaris. They are all very minute species, and these, in turn are infested by smaller parasites belonging to the family Chalcidae. Another parasite of the army worm is the Ophion purgatus Say. It is nearly an inch in length, of a pale reddish brown color, and compressed, sickle-shaped abdomen.

Dr. Fitch also describes a species, Ichneumon leucaniae; several other species are known to infest the army worm. It is a well known fact the number of insect parasites usually increase in proportion to the abundance of their hosts, thus nature keeps in check these destructive insects, which would otherwise, probably, get beyond our control, and it is a question whether the periodicity of the army worm is not due to the increase and decrease of its parasites.

Aside from the true parasites, are a large number of predaceous insects that destroy an immense number, especially true, is this, of several large species of ground beetles, Calosoma calidum, Calosoma scrutator, Harpalus calinosus, and Pasimachus elongatus.

REMEDIES.

Grass lands that have been infested with the worm might be burned over late in April or early May. This will destroy all the eggs deposited, and the chrysalis that are among the roots of the grass, while many of the moths that are nestling in the grass will be destroyed or driven from the field.

Ditching or making a deep trench with steep or undermining sides and furrow in which coal-tar or kerosene has been placed, will do much towards keeping them out of the fields.

In August the writer acting under the direction of Deputy Secretary of Agriculture Prof. John Hamilton distributed several thousand circulars to farmers throughout the State with the following questions:

Did army worms make their appearance in your county this year?
Were they in your section?
About what date did they first appear?
Did they move from one field to another?
How long a time did they remain in your locality?
What crops did they attack?
About what proportion of each crop did they destroy?
What would you estimate your money loss to be?
What means were taken for their destruction?
What was the success of efforts to destroy them?
Have you observed any insects, birds or other enemies of these worms destroying them?
If so, please give names of such destroyers.
The loss in my township through the ravages of the worms is probably $..... The loss in this county will be $.....

LOSS ABOUT $300,000.

About one thousand answers were received to these circulars and from them it appears that the estimated damage amounted to fully $300,000.

The following are some replies from prominent and representative farmers in different counties of the State:

MR. W. R. RAMALEY, Cochran's Mills, Armstrong county, Pa.:

The army worms were in this county in small numbers and a few were in this section. They appeared July 20th, and are here yet, August 4th. They did not move from field to field. I saw them only in the oats. The proportionate loss is very little, not more than one per cent. No means were taken for their destruction.

MR. T. B. KING, Ceres, Allegheny county, New York.

The army worm made its appearance in this section about July fourth, moving from field to field, attacking the oats, grass, corn, millet, etc., and destroying nearly everything where they were numerous. The oats was hurt the worst, having all the leaves and oats trimmed off, leaving the stalk bare and the ground covered thick with it. Ditches were dug to head them off with good success. Birds, chickens, etc., are very fond of them, as they sometimes have parasites stuck to them.

My loss may be $40, and that of the township $1,000.

MR. L. L. BOOK, Eldorado, Blair county, Pa.:

The army worms made their appearance in this county, but there were very few in this section. They appeared July 15th, and remained one month. They attacked mostly grass and some oats, but the damage was slight so far as my knowledge goes.

Nothing was done to kill them. The sparrow will destroy them. They were mostly in Altoona City.

MR. A. L. McINTIRE, Hollidaysburg, Blair county, Pa.:

The army worms were in this county and on my farm, appearing July 5th and remaining about ten days or two weeks. They attacked the oats destroying one-half in some fields; in others one-fourth. My loss is $10 or $20.

MR. FRANK M. GLASSCOW, Bellwood, Blair county, Pa.:

The army worms made their appearance in this county and in this section appearing about July 10th and remaining two weeks. They attacked oats, wheat, grass, etc.; about the only thing they did not take was the broad leaved plantain. They destroyed about one-half of the crops in some places; all in others, especially where lodged.

I had calculated on forty bushels per acre if they had not touched it. No means were taken for their destruction; could not see them at work; could see them in daytime under old cornstalks by dozens; three sizes, big, medium and little. I did not see birds destroying them. A neighbor saw blackbirds unusually plenty among his oats, and thought they were after the worms.

They did not harm anything but oats and only one field; truck patch adjoining field of oats and did not see any on cabbage or vegetables. Could not say as to loss in township, as several fields were not disturbed; they ate all the blades off.

MR. S. R. SCHMUCKER, Cove Forge, Blair county, Pa:

The army worm was in this county and in this section appearing July first and remaining one month. They attacked millet and oats. No means were taken for their destruction. Hogs destroy them very rapidly and are fond of them. Potato bugs will destroy them, but not for food. My loss is $150, and the loss to the township will probably be $5,000, and to the county $25,000.

MR. HENRY HAWK, Altoona, Blair county, Pa.:

The army worms made their appearance here, but were not in my section. Here and there they attacked a lawn, but not very severely; I know nothing definite as to the proportionate loss of each crop attacked. I heard of one who used coal oil and burned them; another used paris green in water and sprayed them with success. I have heard that sparrows destroy them.

MR. HENRY VAN ALLMAN, Frankstown, Blair county, Pa.:

The army worms made their appearance in this county and in this section about the 20th of July and remained two weeks. They did not move, were seen only on one field. The oats is all they worked on, destroying about half the crop. The loss to the township is about $150, and to the county fully $2,500.

MR. JOHN C. PIOLLET, Wysox, Bradford county, Pa.:

The army worm was scattered all through the county; they were in some fields in this section and across the road there would be none. I first discovered them July 9th in the road. I think they moved from the wheat stubbles across the road to the oats. They attacked the oats; would eat the green oats first, just in the milk, would strip all the kernels and leaves and let the stalk entirely bare. Did most of their damage in three days. They destroyed about one-half of thirty acres of oats and ten acres of another field entirely; ate every kernel off the stalk. My loss is about $300 on these fields, and three miles from here they destroyed about twenty acres more, equal to $150. I plowed a furrow around the field, but it did no good; also used a lump roller in the roads to keep them from cross-

Destruction of Oats by Army Worm

ing. I could not see that anything destroyed them; when they got filled up they stopped eating. After ten days or two weeks there would be a coating or shell form over them, similar to a cartridge, brownish in color and pointed at one end; in ten days more a butterfly would come out of this shell.

MR. E. T. BENDER, Stevensville, Bradford county, Pa.:

The army worm made its appearance in this county in great numbers and were in this section. They appeared July 12th and remained about four weeks. They attacked oats, corn, new seeding and meadows, destroying all new seeding; three-fourths of oats; one-fourth of corn and all young grass in meadows.

One pint of salt to two gallons of water will kill them; I tried paris green on corn and it killed both corn and worms; we had best results from salt and water. Blackbirds, robins, bobolinks, meadow larks and young turkeys are very fond of them.

The loss to the township will probably be $2,500, and to the county $5,500.

MR. S. A. LINDLEY, Canton, Bradford county, Pa.:

The army worm was in this county and in this section, appearing July first and remained three weeks. They moved from field to field; first attacking new seeding in the oats, second, the oats, and third, the corn; destroying fourteen acres of oats and one acre of corn bordering the oats. My money loss is $125 to $150, besides the seeding; the loss to the township will probably be from $300 to $400. Fields surrounded by a deep furrow with horse and log at work continually in the ditch, I think saved fifteen acres of silage corn adjoining oats. Domestic fowls, sparrows, blackbirds and a large fly similar to the house fly seemed to kill them.

MR. H. G. WRIGHT, East Canton, Bradford county, Pa.:

The army worms made their appearance in places in this county and were in this section. They were first noticed about July first and remained fifteen days and moved to some extent where they were not prevented. They attacked the oats mostly, corn, tobacco and new seeding and where they worked on lawns they ate there until they looked completely dead. They destroyed nearly the whole crop of oats, where the worms were very thick, but where they were not abundant they seemed to work only on the straw.

Some dug trenches around the corn and tobacco six inches deep and they would crawl in this ditch and could not crawl out over the loose dirt; they then would hitch horse to small log and draw it in this trench with pretty good success. The sparrow, blackbirds, turkeys, skunks and a fly larger than a common fly and of a

grayish color but am unable to say what kind of a fly it was destroyed them. The probable loss to the township is $600.

MR. JAMES HAWTHORNE, Windfall, Bradford county, Pa.:

The army worm made its appearance in a number of places in the county and they were in my section about one mile away. They appeared about July 10th and remained from ten days to two weeks. They moved, but believe they bred in the soil and did not do much harm after they began to move. They attacked oats, corn, clover and timothy destroying in some places about one-third the crop and in others the entire crop.

A ditch was dug nearly perpendicular towards the crop and then a log drawn through it was tried for their destruction; also water and oil were put in; they were drowned in large numbers, also ground up with the log and burned with kerosene. Sparrows have eaten a large number of them so they could scarcely fly; also another small bird seeming to be a new comer this and last summer. In nearly every case of harm by worms the land was in a high state of cultivation, often from tannery manure and manure from livery stables in towns; believe land rather poor and manured with phosphate has escaped. I believe they bred in the soil where they worked the most.

MR. A. S. ROCKWELL, Troy, Bradford county, Pa.:

The army worms made their appearance in this county and in this section. They appeared the first of July and remained three weeks. They moved in some places where they were very thick. They attacked oats, corn and new seeding; most damage was done to new seeding destroying nearly one-fourth of it and oats. My loss is about $75.

I do not know of anything being done in my neighborhood for their destruction; in some places they used salt to keep them from crawling; the worms did not like the salt very well. The crow and the skunk destroys them; I found a good many sods and stones turned over in the night by skunks hunting for the worms; they were quite thick under stones. The loss to the township will probably be $1,500, and to the county $30,000.

MR. H. W. COMFORT, Fallsington, Bucks county, Pa.:

The army worms made their appearance in this county and in this section about July first and remained from four to ten days. They moved from field to field attacking the young grass in the wheat fields mostly; also a few fields of corn and oats; destroying all of the young grass and one-sixth of the corn and oats. My loss is ten acres of young grass; other fields in same farm were not hurt. No means were taken for their destruction. I did not observe birds, insects or other enemies destroying them.

MR. JOHN MAGILL, Carversville, Bucks county, Pa.:

The army worms were in this county and in this section appearing about the 20th of July and remained a week attacking the oats, destroying from one-fourth to one-tenth the same; other crops not worth mentioning. No means were taken for their destruction; some thought the common blackbird destroyed them, as they flocked in fields where the worms were and the worms disappeared.

MR. A. W. PRESTON, Solesbury, Bucks county, Pa.:

The army worms were in this county but not in my section, appearing about the first of July, attacking the oats, destroying a very small proportion, possibly three bushels to the acre. Nothing was done for their destruction.

MR. F. L. MULFORD, Edgewood, Bucks county, Pa.:

The army worms made their appearance in this county and were on a neighboring farm. They did not move to any appreciable extent. They appeared about June 25th remaining from two to three weeks. They attacked the oats chiefly, some spring rye and a little corn. The worst field destroyed was about half eaten, but only a few fields were badly affected. Nothing was done to destroy them, nor did I observe any birds or insects destroy them. The loss to the township will probably be $1,000.

MR. CYRUS T. FOX, Reading, Berks county, Pa.:

The army worms made their appearance in the north eastern, extreme eastern and western districts of this county and were not in the vicinity of Reading. They appeared the latter part of June, remaining from two to three weeks. They are reported to have moved though they did not cover a very large area. They attacked chiefly the oats crop, clover, timothy and some other grasses, destroying about fifty per cent. of oats on several farms and possibly twenty to twenty-five per cent. of grass.

Ditches were dug and kerosene applied for their destruction; there seemed to be a general ignorance as to what to do, until through the newspapers the Department of Agriculture enlightened the people. When the efforts were persistent the results were generally satisfactory. The English Sparrow is said to have been effective in its attacks upon the army worm, also the lady bug. The probable loss to the county will be $3,000.

MR. GEORGE D. STITZEL, Reading, Berks county, Pa.:

The army worm was reported to have been in several sections of the county, but was not in the immediate vicinity of my farm. They appeared from the middle to the latter part of June and remained from two to four weeks. They attacked principally the oats; the wheat was too far advanced and was being harvested. Reported

in a few instances to have destroyed as much as fifty per cent. of the oats. The loss to the county is probably $3,000.

The people seemed at a loss what to do to kill them and when informed the worms had disappeared. The English Sparrow is said to have made war upon them.

MR. WILLIAM PEARSON, Calcium, Berks county, Pa.:

The army worms made their appearance in this county and in this section, appearing July first and remaining about a week. They moved from one field to another attacking the oats and corn observably, but think they passed through the wheat fields and ate the leaves from the clover, but not killing the plant as the weather was favorable for it to shoot out again. They destroyed about three per cent. of the oats; corn very little if any killed; but eating of the leaves must have been some damage. My loss is $15. Paris green was dusted on a few rows of sugar corn that appeared to be eaten up and they certainly did very little injury beyond these outside rows that were dusted; but that seemed to have been their way of operating, that is, just eating the oats along one side of the field, ten to fifteen feet wide, although they may have gone further in scattering they did not do much damage.

MR. M. LONG, Mertztown, Berks county, Pa.:

The army worms made their appearance in this county, they were about three miles west of us and two miles south. They appeared the middle of July and remained from ten to fourteen days. They moved from one field to another. They attacked oats and meadow grass; orchards sown with oats seemed preferable. I have seen two orchards totally destroyed; what I have seen may be ten acres totally destroyed and twenty partially. The English Sparrow kills them.

MR. OLIVER D. SCHOCK, Hamburg, Berks county, Pa.:

The army worms were in this county and in my section, appearing the second week in July and moved from grain to grass field. They attacked oats, grass and corn, but did no serious injury to corn; greatest harm was inflicted upon the unripe oats; comparatively, only a small proportion of each crop was destroyed. The loss is $1,000 in northern Berks. The means taken for their destruction was ditching principally; common resources and insecticides were unavailing; the success was only partial. Birds in limited numbers and species, poultry, certain beetles, parasites, &c., were the destroyers.

MR. WILSON F. KAUFMAN, Blandon, Berks county, Pa.:

The army worms made their appearance in this county and in this section about July 20th, and remained a week or ten days.

They moved from one field to another, attacking the young clover, oats and wheat, destroying three-sixteenth of the crop. My loss is $50. No attempt was made to destroy them; sparrows, robins and beetles destroyed them. The loss to the township will probably be $300, and to the county $1,000.

MR. G. W. OSTER, Osterburg, Bedford county, Pa.:

The army worms were in this county and in this section, but not as plentiful as in some parts of the county. They appeared July 15th, and are here yet, August 6th. They moved from one field to another. They attacked the oats in this locality and are cutting corn badly now in parts of the county, having destroyed from five to eight per cent. of the oats here, while for some neighbors two or three miles distant, they cut from forty to sixty per cent. My loss will hardly exceed $10 or $15, while some neighbors will reach $100. The loss to the township will probably reach from $1,000 to $2,000, and to the county from $10,000 to $20,000. No means were taken for their destruction.

MR. ISAAC B. REPLAGLE, Jr., New Enterprise, Bedford county, Pa.:

The army worms made their appearance in this county and were on neighboring farms. They were first noticed the middle of July and remained about three weeks but only staying about twelve days in one place. They attacked the oats, timothy and other small grasses destroying about one-eighth the grass and about one-half the oats; my loss is nothing as the worms were not on my place; the probable loss to the township will be $1,000 and to the county $2,000. Some plowed furrows ahead of them; this worked right well until it rained; paris green was used by some with pretty good effect; blackbirds, chickens and hogs seemed to work on them.

MR. JOHN E. RITCHEY, Loysburg, Bedford county, Pa.:

The army worms made their appearance in this county and were on the farm where I live. They were seen here about July 10th, and remained from twenty to twenty-five days. They moved from field to field and across the road attacking oats, barley and timothy principally; they attacked the corn but did not remain long enough to damage it. They destroyed at least one-half, probably three-fourths of barley and oats. Seventy-five dollars is about my individual loss. To plow a furrow in front of them were the means used to destroy them, but success was poor as the first rain packed the ground and let them pass. The robin, blackbird, English sparrow, all domestic fowls and hogs destroy them.

MR. SAMUEL J. KEITH, Woodbury, Bedford county, Pa.:

The army worms were in this county and in my section, appearing July first and remained from four to six weeks. Short grass

fared the worst, such as pasture grass; oats came next as they cut the grass off. I saw where the ground was at least one-half covered with oats cut out from the straw by said worms. From one-fourth down to one-tenth of the crops were destroyed; some localities were not harmed much. The loss to the township is about $200. Ditches were plowed around the fields, banks of dirt thrown up and even large strips plowed round the fields; even the pavements were guarded to prevent them from crossing; it proved to be of good success in many ways. I do not know of any birds or insects destroying them.

MR. R. OPPENHEIMER, Oppenheimer, Bedford county, Pa.:

The army worms made their appearance in this county and in this section. They appeared July 20th and remained ten days. They did not move from one field to another. Attacked the oats and corn destroying about one-third of the fields they were in. My loss is about $40. The loss to the township will probably be $500. Crows were in the fields in large quantities apparently picking them up. Experience proved the worms as taking to the ground in daylight and coming out and feeding after sundown. By turning clods of earth they would be found in large quantities, also digging holes for themselves to hide in.

MR. W. CLAY LUTZ, Lutzville, Bedford county, Pa.:

The army worms were in this county, but were not in my immediate vicinity, but in the township. They appeared from the middle to the last of July and remained a week and attacked the oats destroying very little of the crop as they kept on the border of the fields. No means were taken for their destruction as far as I know.

MR. E. N. FAIRCHILD, Sizerville, Cameron county, Pa.:

The army worms were in this county and in my section, appearing June 30th and remaining twenty days. They attacked rye, oats, corn, grass, gardens and in some places the forest trees; destroyed in some sections rye and oats totally; corn, two-thirds; grass, total; the loss to the township will probably be $5,000, and to the county, $10,000. No means were used to destroy them to any amount; some tried kerosene oil, which seemed to check them.

MR. W. W. WAYNE, Hudsondale, Carbon county, Pa:

The army worms were in this county about ten miles from here on the poor house farm appearing, August first and moved from field to field attacking oats, destroying three-fourths of the crop in the fields where they were; the loss to the county will be $500. They plowed around the fields to prevent them spreading without success, but did nothing to destroy them.

MR. CHARLES SCHUCHOLTZ, Rock Port, Carbon county, Pa.:

The army worms made their appearance in this county to a great extent and did a lot of damage all around this section. They made their appearance about July 10th and remained a week and a half. They attacked the oats, at least that is all I could discover, destroying about twenty-five per cent. of the crop. I would estimate my loss at $25. We plowed furrows around the field and shoveled out trenches to keep them from going farther; we succeeded so far that there was no trouble with them; it might have been that it was out of season for them.

MR. M. A. MEYERS, Clintondale, Clinton county, Pa.:

The army worms were in this county and in this section. They appeared the last of June and remained six or eight weeks. They attacked the hay, oats and wheat; they seemed to have a decided preference for oats, destroying, in some instances, about one-fourth the crop. Nothing was done to destroy them.

Some of the farmers doubt whether we have the real army worm; they say it resembles the cut worm, but it not so large and varies more in color; they are supposed to do their work chiefly at night and are hidden in the ground by day.

J. M. DUMN, M. D., Mackeyville, Clinton county, Pa.:

The army worms made their appearance in this county and were in this section. They appeared about July 25th attacking the oats, destroying about one-fifth of the crop where they worked. My loss is perhaps from three to four dollars. The loss to the township will probably be $300.

No means were taken for their destruction.

MR. J. A. HERR, Cedar Springs, Clinton county, Pa.:

The army worm made its appearance in this county and in this section. They appeared the first of August and remained ten days. They did not move from one field to another. They attacked the oats and grass and in a few instances they destroyed one-fourth the crop. The loss to the township will probably be $50.

No means were taken for their destruction.

MR. S. D. PATTERSON, Vetera, Cambria county, Pa.:

The army worms were in this county, but not in my immediate section appearing July 25th and moved from one field to another attacking oats, corn and young clover, principally oats. Some used kerosene; others salt and some plowed ditches to destroy them.

MR. JOHN A. NOLL, Loretta, Cambria county, Pa.:

The army worms were in this county and in our section, appearing about the third of July and disappearing August 20th, attacking wheat, rye and oats, destroying one-third of fall grain, and

one-half of oats; my loss is $75, the loss to the township is probably $1,000. Some plowed ditches while others used salt with good results; cutting the grain and allowing the sun to shine on them killed them at once; crows, toads, robins and ground birds destroy them.

MR. JOHN BEHE, St. Augustine, Cambria county, Pa.:

The army worms made their appearance in this county and in my section and remained about twenty days. They attacked young clover and timothy, cabbage, oats, corn and garden truck destroying some of the crops two-thirds; the loss on each farm would be about $200; the loss to the township will probably be $1,000. Some farmers used paris green on corn, but destroyed the corn; salt was the only remedy that took any effect and where it was used the success was good; where a train of salt was placed around vegetables the worms would not cross it. Chickens, turkeys and hogs will eat them.

MR. H. J. HOPPEL, Carrolltown, Cambria county, Pa.:

The army worms were in this county and within five miles of my farm. They appeared July 25th and moved from field to field attacking oats, the other crops were harvested, destroying about one-half the oats crop; in the locality where they were would estimate the loss to be from five to six hundred dollars; the probable loss to the county will be $2,000. Some tried salt to destroy them but were not successful.

MR. JOHN F. THOMAS, Patton, Cambria county, Pa.:

The army worms were in the southeastern part of the county and were within one-half mile of my farm. They made their appearance the first of July and are here yet. They have been moving towards the northwest, attacking the rye first; they are now working on the oats and corn; on the latter they seem to make little headway. Furrows were made with a plow for their destruction.

MR. JOHN S. McCOY, Chest Springs, Cambria county, Pa.:

The army worm made their appearance here about July 20th. I heard of them destroying one field of barley. No means were taken for their destruction; turkeys and geese are very fond of them. The loss to the township will probably be $1,000.

MR. GILBERT HOOVER, Kylertown, Clearfield county, Pa.:

The army worms were in this county and in our section, appearing about the first of July and remained a month. They did not move from field to field. They attacked oats and grass, destroying a twentieth part of the oats, the grass a mere trifle. The loss to the township will probably be $100, and to the county $1,000. There were no means taken for their destruction.

MR. W. B. KRATZER, Keewaydin, Clearfield county, Pa.

The army worms made their appearance in this county and in this section on July first and remained two weeks. They moved from field to field, attacking grass, corn, rye and oats, eating the grain off the oats, and the leaves of the corn; first the blade and then the top of the grass; they eat the grain from the rye. The loss to the township is probably $200. I only had them in a field of grass on my farm and when I discovered them they had eaten about one-fourth of an acre. I mowed the patch and one swath outside where they were; I then made a solution with paris green and water and sprinkled two feet wide next to the standing grass, and that was the end of them. When they went to the corn it was cut off and burned. I did not observe any birds or insects destroy them.

MR. E. ASHENFELTER, Redfern, Clearfield county, Pa.:

The army worms were in this county and in my section, appearing about July 14th, attacking millet and oats; millet half matured had to be cut, never sprouted. In oats out in lodged places burned straw on stubbles and saw no more of the worms. Chickens destroy them. The loss to the township is probably $100.

MR. ZENAS SHAW, Clearfield, Clearfield county, Pa.:

The army worms made their appearance in this county the last of July, and to my knowledge did not move much. They attacked the oats and wheat, destroying about one-third of the oats; did not hurt the wheat, but ate the young timothy. No means were taken to kill them; the crow and flicker will destroy them. The probable loss to the township will be $25.

MR. PETER GEARHART, Curwinsville, Clearfield county, Pa.:

The army worms made their appearance in this county and in this section. They appeared July 20th and remained two weeks, moving from one field to another. They attacked the oats, destroying more than one-half the crop. The loss to the township is probably $500.

MR. W. M. ZELLER, Shippensburg, Cumberland county, Pa.

The first I noticed them was about two or three weeks before harvest. My farmer said he noticed streaks of dead wheat last fall and in the spring when he sowed grass seed. I helped cut and haul in the wheat and it looked as if an army had marched through it; they went due north and south, about three and a half feet apart through the whole crop—forty-two acres. I did not see a worm until we came to haul in the wheat under the shock we found a few; since then we have found a few under clods and stones; they appear to be

very savage when attacked. They destroyed about one-tenth of the crop. I should estimate my money loss to be about seventy-five cents per acre on forty-two acres.

MR. R. H. THOMAS, Mechanicsburg, Cumberland county, Pa.:

The army worm appeared in several localities in this county. I did not see any in this section, but heard of a few a couple miles away. They appeared the latter part of July, remaining a week or so. They attacked cereals, but the damage did not amount to much. No special remedy was used for their destruction; each man fought them on his own plan. The invaders appeared in too small numbers to attract much attention or excite any alarm.

MR. JOHN F. RUPP, Shiremanstown, Cumberland county, Pa.:

The army worms made their appearance in this county and were within three miles of us. They appeared the beginning of July and remained about two weeks. They attacked mainly the oats; slight damage to the corn; the grass and wheat being nearly all cut the time the worms appeared. The oats suffered considerably; some fields one-third destroyed. Sparrows ate them with avidity; sparrows in hundreds were along the furrow; chickens and turkeys are also very fond of them and ate a great many. Plowing furrows around patches of the worms or around the entire field was tried with satisfactory results.

MR. D. E. LONGSDORF, Mechanicsburg, Cumberland county, Pa.:

The army worm made its appearance in this county from July tenth to fifteenth and remained two weeks. They attacked oats and corn. Some made ditches to keep them off the corn in which many were destroyed. Sparrows, robins, chickens and turkeys destroy them. The plowed ground seemed to retard their progress and gave the birds a chance at them. They were so numerous that at sundown a rushing noise could be heard over the field caused by the movements of the worms. They do their work at night and seek shelter during the day.

MR. HERBERT E. BLAKESLEE, Spartansburg, Crawford county, Pa.:

The army worms made their appearance in this county and in this section. They appeared the 15th of July and remained until August first. I did not notice them move on my farm, but heard they did on others. They attacked late oats, sweet corn, gardens, raspberry and hop vines, destroying all the hop and raspberry vines and about one-third the oats.

I did nothing to destroy them; some plowed furrows around the field to keep them enclosed; it only stopped their traveling. Blackbirds, bobolinks, robins and ground birds were thick on the fields after the worms.

I could not give the money loss, but about one-third of the crops were destroyed in this vicinity.

MR. F. SOUTHWORTH, Little Cooley, Crawford county, Pa.:

The army worms were in this county and in my section appearing July 25th and remained about three weeks. They attacked corn and oats destroying about fifteen per cent. of the oats and four per cent. of the corn; they did not infest my place, but were on an adjoining farm; the loss to the township will be $450, and to the county $16,000. No means were taken for their destruction; I observed the crow and English Sparrow destroy them; the sparrow seemed to work on them in the early morning before the worms went back into the ground (which they do in daytime); the crows seem to be able to picked them from the ground and worked more or less all through the day.

MR. WILLIAM B. GILSON, Vrooman, Crawford county, Pa.:

The army worms made their appearance in this county and in this section about July 15th, and remained two weeks. They attacked oats, corn, hay and pastures and where they attacked a field of oats they usually took from one-half to two-thirds.

Some plowed around their crops; others used crude oil; some cut their oats green, but there were worms in the bundle; others hauled theirs off to another field to save it. Crude petroleum will kill them if gotten on them; that is all we found to kill them, salt is no good. I noticed large flocks of crows working on the fields where the worms were; also a little blue fly that lit on the worms back.

MR. F. A. MARYOTT, Guy's Mills, Crawford county, Pa.:

The army worms were in this county and in my section, appearing July 10th and remaining two weeks. They moved from field to field attacking the oats, corn, grass and wheat, destroying about one-fourth of the pieces attacked. Ditches were dug heading them off, and when they went into the ditch they were covered with the dirt; when these measures were resorted to they were a success: sparrows destroyed them. The loss to the township will probably be $100.

MR. J. T. WILSON, Millville, Columbia county, Pa.:

The army worms were in this county and in my section, appearing the middle of July and remained two weeks. They attacked the oats and in some fields the crop was one-half destroyed; some fields about ten bushels per acre; the loss to the township will probably be $300. Paris green sprinkled on green oats and covered; plowed furrows filled with straw and burned were the means used to kill

them. Paris green killed some and so did burning. The robin, chippee, ground sparrow (not English) and a parasite which kills the larvae destroys them.

MR. J. H. ECK, Berwick, Columbia county, Pa.:

The army worms were in this county and in my section appearing about the 10th of July. They appeared to hatch in the fields, attacking the oats, corn and timothy, destroying all the oats in some fields; corn not damaged so much; my loss is perhaps $50; the loss to the township will probably be $2,000. Some plowed furrows to keep them confined in one field; there was not much success in destroying them as they seem to bury in the ground to hatch. Tre sparrow destroys them ;in a small field near town the sparrows in the evening as the worms made their appearance would visit it in large numbers.

MR. H. H. BROWN, Light Street, Columbia county, Pa.:

The army worms made their appearance in this county and in this section, appearing July 10th and remaining three weeks. They moved from field to field. They attacked the oats mostly; corn slightly and destroyed oats on moist lands in certain fields entirely, except the straw; in other fields they bit off from one-twentieth to one-tenth of the oats. On corn they eat the tassel before coming out, but did not hurt it to any extent. In this township the loss to the oats crop will not amount to more than one-fourth the crop. No means were taken for their destruction; after the oats was harvested my fowls traveled over the field and eat those that were partly uncovered as they were then in the cocoon state. The loss to the township is probably $500 and to the county $10,000 to $12,000. I tried a solution of banner lye, which killed them.

MR. W. J. BEIDLEMAN, Bloomsburg, Columbia county, Pa.:

The army worms made their appearance in this county for the first time we have any knowledge of; they were not in many fields, but were destructive where they were. They appeared the middle of July and remained from ten days to two weeks, attacking the oats principally; late corn slightly; grass very little; when they attacked an oats field they destroyed it entirely, leaving only naked stalks Few made any efforts to destroy them; we saw deep furrows plowed around the fields; coal-tar put in furrows; paris green tried with some other ineffective means resorted to; plowing furrows and putting coal-tar in was the most successful. I have been told the English sparrow was destructive to them.

MR. T. E. EDWARDS, Benton, Columbia county, Pa.:

The army worms made their appearance in this county and in this section about July 20th and remained two weeks. They did

not move from place on my farm but did in some places. They attacked the oats and in some places destroying so much of it that it was not worth cutting; other places about one-third. My money loss would not exceed $20, as they worked on my oats but little; the loss to the township is about $150. I would state that the army worms did not seem to work very much in our township and then they seemed to go into the ground and after a time turn into a bug with wings and disappear.

MR. J. Y. DALE, Lemont, Centre county, Pa.:

The army worm made its appearance in this county and in this section about the middle of July, remaining three or four weeks. They moved from field to field attacking chiefly the oats, but there were a few on the corn, sowed for silo, hungarian grass and one farmer said the young ones cut his clover off just below the surface of the ground; but on investigation this was found to be a white worm about a quarter of an inch long.

No organized effort was made to destroy them, but some plowed furrows around the fields and some used creolin with very little success. Various birds ate them and a small fly deposited its eggs on them. The total destruction is small, though some fields of oats were considerably injured. The loss to the township will probably be $100.

MR. D. A. GROVE, Lemont, Centre county, Pa.:

The army worms were in this county and in this section, appearing July 15th. Only in places they moved. They attacked barley and oats, destroying about one-eighth of the barley and a great deal more of the oats. The loss in our section is about $8,000, and to the township $10,000.

Cutting crops before they were fit and plowing around fields and burning them were tried for their destruction, but were not able to do much. Blackbirds destroy them.

MR. GEORGE NOLL, Milesburg, Centre county, Pa.:

The army worms were in this county and were within a mile and a half of me. They appeared the middle of July. They attacked nothing but oats; some fields will not have the seed on them, others were not hurt so much.

MR. WILLIAM FOSTER, State College, Centre county, Pa.:

The army worms were in this county and in this section, appearing July 15th and remained about two weeks. They did not move to any great extent and attacked barley and oats, destroying probably fifteen per cent. of the crop. My loss is about one dollar per acre on barley and oats. Some dug ditches around their fields, but

I think the wet weather had more to do with their destruction than anything else. The loss to the township will probably be $1,000, and to the county $10,000.

MR. JOHN T. McCORMICK, State College, Centre county, Pa.:

The army worm made its appearance in this county and in this section, appearing July 12th. They did not appear to move, seemed to stay in the oats and barley fields. They attacked oats and barley principally, and I would estimate the loss at four or five bushels per acre. Deep furrows were plowed around the field for them to drop into and then killed by crushing or tramping. This was pretty successful. Sparrows would pick them up, but do not think they relished them as they did other worms.

MR. A. W. STEINRUCK, Deodate, Dauphin county, Pa.:

The army worms made their appearance in this county and in this section about July 15th and remained until oats had ripened. They attacked mainly the oats crop; they attacked grass also but did no damage to any account. Some fields were entirely destroyed. The loss to the township is at least several hundred dollars. No means were taken for their destruction. I have not observed any birds, insects or other enemies destroying them.

Only a few army worms appeared in my immediate neighborhood, but in the lower end of the township some fields of oats were almost entirely destroyed; they appeared only by "streaks," some adjoining fields being void of them. I have not had the opportunity to watch their habits or what birds are enemies to them. If the destruction of birds were entirely prohibited, the much abused crow excepted, the insects enemies would not be so troublesome.

MR. E. D. KEIPER, Middletown, Dauphin county, Pa.:

The army worm appeared in this county and in this section. They were first noticed July 10th, and remained probably fifteen days. I have no knowledge of them moving. They attacked the oats only, destroying in our township about one-third of the crop. My loss is about $75, and that of the township $2,500.

MR. E. O. HASSLER, Harrisburg, Dauphin county, Pa.:

The army worms made their appearance in this county and in my section. They appeared about the first of July and stayed mostly in an eight acre field remaining three weeks. They did not attack any crop worthy of note but the oats; the corn seemed to be hard for them to attack. They destroyed one-fourth of the crop; my money loss is about $30. I drew a deep furrow along the corn field side of the oats, but I did not notice any success in the furrow. I observed the blackbirds and sparrows feeding on them very

freely. Blackbirds were the most numerous. As oats are very cheap the probable loss to the township is $500, and to the county $10,000.

MR. ELI SWAB, Elizabethville, Dauphin county, Pa.:

The army worms were in this county and in our section, appearing July 10th, attacking the oats and young grass, destroying about half my oats crop. I know of no means that were taken for their destruction; my son saw a large worm after the army worm which tried to kill it; I am not able to say any more of my own farm.

MR. I. E. TUTTLE, Union City, Erie county, Pa.:

The army worms were in this county and in this section, appearing about July 10th or 12th, and remained two weeks. They did not move from field to field in my immediate locality, but in others they did. They attacked the oats chiefly; corn, grass and garden truck slightly. In the oats field attacked the loss will average fifty per cent. Acreage destroyed in township is only a small percentage of the whole crop. My money loss is very slight. The probable loss to the township will be from $500 to $1,000, and to the county $10,000. Eggs were evidently hatched in the oats field and as the worms did not move off the crop no remedy could be applied. I did not observe anything destroy them except a little maggot that was discovered working inside the dead worms on a farm two miles from my place.

In nearly every instance where the worms attacked oats in this locality, they first made their appearance in the heart of the field, working outward, first stripping the foliage then cutting off the grain. In a majority of cases by the time half the crop was destroyed the worms were fully developed and untold millions of them are now in the earth in the pupa, at the same time they began to disappear into the earth; vast numbers of them died off from cause not apparent. Further north in the county where the worms moved from field to field, plowing ditches, rolling, etc., were resorted to with good effect in some instances, but with us such means were quite impracticable. It is a curious fact that all through our town certain fields of oats were savagely attacked, while on the same farm or an adjoining one, they would not appear at all. And where they did appear there seemed to be no uniformity of location relative to the position of other fields, pastures, meadows and crops.

MR. HIRAM RICE, Waterford, Erie county, Pa.:

The army worms were in this county and in this section, appearing July first and attacked corn and oats, destroying in many places one-fourth of the oats and in some cases all. My loss was

slight, but that of some of my neighbors was heavy. The loss to the township is probably $200, and that of the county will probably run into the thousands. Many cut the oats before it was ripe to save it; my corn being near the barn I think the chickens destroyed a large number of them. They appear to hatch out in the corn or oats.

MR. H. H. RUSSELL, Belle Valley, Erie county, Pa.:

The army worms made their appearance in this county and in this section to some extent. They appeared July 20th and remained two weeks. They attacked the oats and in some cases the corn in the center of the stalk and in others they ate the leaves, destroying about one-fourth of the crop in the county. In many cases they were seen in the center of the field first and went away as quickly as they came.

One man used salt scattered in a line around the field and they did not cross the line; was not successful in destroying them. The blackbird destroys them. The loss in the township will probably be $1,000.

MR. W. C. JOHNSON, Greenfield, Erie county, Pa.:

The army worms were in this county and in my section, appearing July 5th and remained about three weeks, and then went into the ground. They attacked oats mostly; corn in some cases, and destroyed about half the oats; corn not damaged much. Lime and ashes were used to destroy them, but with little success; I have observed the English Sparrow and blackbirds destroy them. The loss to the township will probably be from $7,000 to $8,000.

MR. W. W. STRYKER, Petersburg, Huntingdon county, Pa.:

They were in this county; appeared in this section July 20th. They attacked the oats and I saw some under the timothy where it was down; they did their work at night, could not stand the hot sun. They destroyed about five bushels of oats per acre; did not hurt the grass any. My loss is about $25. The common blackbird destroyed them. About five hundred worked in my field for four or five days, then they disappeared. The loss to the township will probably be $500.

MR. E. B. HARENCAME, Norrace, Huntingdon county, Pa.:

The army worms were in this county and in this section, appearing about the middle of June and remained six weeks. I do not think they moved. They attacked the oats; no other grass or grain that I know of was hurt; they attacked my garden and took half my cabbage. They have destroyed in places nearly whole fields of oats; I can not give you the proportions; my loss is light; the loss to the township will probably be $500.

We put salt around our cabbage and that seemed to stop them; no other means were tried.

Effect of Army Worm on Field of Rye

MR. W. T. BROWNING, Orbisonia, Huntingdon county, Pa.

The army worms were in this county and in my section appearing June first and remained about six weeks, attacking oats only and destroying about eight hundred bushels out of nine hundred of oats; my money loss is $200; the loss to the township is probably $1,000, and to the county $5,000. We did not try anything to destroy them; the English Sparrow will destroy them.

I did not get my oats sown until May; I think if I had gotten it sown earlier the worms would not have been so bad on it as in the neighborhood oats that was sown early were not touched by them. My corn field adjoins the oats field with only a worm fence between, but the worms did not seem to attack the corn, but took all the oats and may be the reason that I did not disturb them is the reason they did not attack the corn. They did their work at night.

MR. G. M. DELL, Mapleton Depot, Huntingdon county, Pa.:

The army worms were in this county and in my section, appearing July 17th, and remained about three days, attacking corn, oats and grass; about one-fourth of the oats were destroyed; my loss is $20; the loss to the township is probably $100, and to the county $1,000. No means were taken for their destruction; I have observed birds destroying them, the English Sparrow being the principal one.

MR. SIMON ULSH, Mifflintown, Juniata county, Pa.:

The army worms were in this county, but not in my section. They appeared July 20th and remained until the oats got too hard. They worked on the oats principally; some say they worked on the corn a little, destroying about five per cent. of the crop. Nothing was done to destroy them; I know of no birds or insects that destroy them.

Mr. MATTHEW RODGERS, Mexico, Juniata county, Pa.:

The army worms appeared in this county and in my section about July 18th, and remained from ten days to two weeks. The oats crop was the only one that was severely damaged; in a few cases where the corn joined the oats a few rows would be entirely destroyed. My loss is $45. The loss to the township $1,000, and to the county from $1,000 to $1,500.

MR. HARVEY EMERY, Kizers, Lackawanna county, Pa.:

The army worms were in this county and in my section, appearing about the 1st of July and remained two or three weeks. In some cases they moved from field to field, attacking oats, corn, new seeding in the oats and in some cases the pasture, destroying about one-half of the oats crop; one-fourth of the corn; new seeding entirely destroyed; my loss is about $100, and that of the township

probably $2,000. In some instances ditches were dug where they were crawling from one field to another to destroy them.

MR. MICHAEL FOLEY, Mount Cobb, Lackawanna county, Pa.:

The army worms made their appearance in this county this year and were in my section. They appeared the first week in July and remained three weeks. They did not move to any extent, but where there were oats and millet in the same field they would leave the oats and go for the millet. They attacked oats and millet principally, but in towns they attacked and destroyed lawns. I am inclined to think they hurt new seeding to a considerable extent. They destroyed at least one-half of the crops; there were three acres of which I saved nothing but the straw. $75 is a moderate estimate of my loss. The probable loss to the township is $1,000, and to the county $2,500.

Some sprayed with turpentine and water, others with kerosene and water to destroy them; they did well on lawns, but the best for oats is to sow about four bushels of salt per acre.

A fly somewhat larger than the house fly seemed to be a great enemy to the worms; I cannot name the fly.

MR. DAVID WHITE, Tomkinsville, Lackawanna county, Pa.:

The army worms were in this county and in my section, appearing about July 10th, and remained three weeks, attacking oats, corn, pastures and timothy, destroying over one-half the oats; my loss is about $200; the loss to the township will probably be $2,000. Plowing deep ditches, sowing salt, and the use of paris green on corn cut fine and put in the ditch killed a large number of them. I observed crows and barnyard fowls destroying them.

MR. H. W. NORTHUP, Glenburn, Lackawanna county, Pa.:

The army worms made their appearance in this county and in this section on July first and remained two or three weeks when they went into the chrysalis or pupa state after crawling under stones. They did move; in some places the ground was nearly covered with them. They attacked oats, grass, rye and corn. Oats are their favorite food; they prefer them to anything else; they crawl up the stalk, first eat the leaves, then the head and the grain mostly falls to the ground. They destroyed nearly everything they met, except the stub or woody fibre which they rejected. They were only in spots where they worked. My farm was highly favored, but one or two of my neighbors lost a whole field. One farmer cut his and raked it up for hay; another cut his and put it in the silo; one farmer paris greened the edge of his corn and poisoned them as they were coming on to it and stopped them; some cut a swath around the field and then plowed about two furrows for them to fall into when they were coming into the field. If the worms were not too

strong the above method checked them. After they had entered the pupa state I turned over stones where they were lying and saw black bugs destroying them, having them partly eaten.

MR. JOHN G. BATDORFF, Millbach, Lebanon county, Pa.:

The army worms were in this county and in this section, appearing the first of July and remaining from five to six weeks. They attacked grass, corn and oats destroying about one-third of the oats on eleven acres. They moved from hay to corn and oats fields. Nothing was done for their destruction.

MR. J. M. BENTZ, Lawn, Lebanon county, Pa.:

The army worms were in this county and in my section appearing about the 10th of July and remained two or three weeks. They attacked the oats, destroying some fields entirely while others were not touched. The loss to the township is probably $2,000. No means were taken for their destruction.

MR. W. E. BRUNNER, Campbelltown, Lebanon county, Pa.:

The army worm appeared in this county and in this section. They were noticed July first, remaining from ten to fifteen days. They moved from field to field and attacked wheat and oats, destroying very little wheat and about two per cent. of oats. Nothing was done to destroy them. Sparrows will destroy them. The loss to the township will probably be $500.

MR. H. L. ILLIG, Millbach, Lebanon county, Pa.:

The army worms made their appearance in this county and in my section about June 15th, and remained one month. They moved from one field to another, attacking the oats principally, besides doing slight injury to corn and grass along fences. Reports as to the damage done the oats crop are conflicting, but may reach twenty per cent. in this section; to corn and grass possibly two per cent. My individual loss may reach $30. The loss to the township may be $500. To my knowledge nothing was done to destroy them in this section. I observed blackbirds ate them following the worms in large flocks.

MR. J. H. BASSLER, Myerstown, Lebanon county, Pa.:

The army worm was in this county and in this section. It appeared July first. They moved from field to field unless prevented by a furrow around the field. They attacked principally the oats; grass to a small extent; corn still less. There are fields of oats three-fourths destroyed, but these cases are rare. No means were taken for their destruction that I know of. I have not observed them, but acquaintances of mine say that the robin destroyed them.

MR. FRANKLIN FRANCK, Kingston, Luzerne county, Pa.:

The army worms were in this county and in this section, appearing the first of July and remained two weeks. They moved from field to field, attacking the grass, rye, oats, wheat and some corn, but grass and oats seem to be their favorite diet.

Plowing furrows around the field infested and digging holes several feet deep in the furrow and ten to fifteen feet apart were the means used for their destruction. The efforts were only partly successful as many of the worms escaped. English sparrows seemed to feed on the worms and destroyed large numbers of them.

MR. H. B. LARNED, Huntingdon Mills, Luzerne county, Pa.:

The damage the army worms have done to crops near Huntingdon Mills is not as great as in other portions of the State. A five acre field of oats on the farm of Harry Davenport, that would have yielded forty or fifty bushels per acre, was entirely destroyed, nothing left but the stalk; where the oats stood up they did not do so much damage. When I visited the above field there was now and then a stalk of buckwheat which stood unharmed, while there was not a kernel left on the oats around it. Have not heard of their working buckwheat or potatoes; oats, corn and timothy suffered most, a few fields of wheat and rye have been damaged. Where they work in small grain the young clover and timothy goes first, apparently killing it entirely. I do not know of any place around here where they are doing much damage now, all have gone into the ground; they are found in many places where they have done no damage. They have worked on some farms very badly, while an adjoining farm will be free of them.

I know of ten or twelve farmers who will lose from $25 to $200.

MR. W. R. IDE, Idetown, Luzerne county, Pa.:

The army worms were in this county and all around me. They appeared about the first of July and remained two or three weeks, attacking oats, grass and corn and destroying some fields of oats entirely. The loss to the township will probably be $500. The chickens and English sparrows were fond of them.

MR. CHARLES D. KUNKLE, Kunkle, Luzerne county, Pa.:

The army worms made their appearance in this county and in this section. They appeared July 18th and remained two weeks. They attacked the oats and for some destroyed the whole crop and for others not so much. My loss is about $10. The loss to the township will probably be $600.

Ditches were plowed and holes dug at intervals of three feet and kerosene poured on them. The success with ditches was good as they accumulate pour kerosene on them which kills.

Quails, larks, sparrows and birds of all kind destroy them, but the worms appear in such large numbers that they are little help.

MR. F. A. SNYDER, Shavertown, Luzerne county, Pa.:

The army worms made their appearance in this county and in my section about July 4th and remained three weeks moving from one field to another, attacking rye, oats and corn. The loss to the crops is from five per cent. to fifty, and as much as ninety; my loss is five or ten dollars, if the seed is not spoiled; they cut three acres of rye and eat the grass out; the loss to the township will be $500. Some plowed a ditch around their oats and dug holes every rod or more for them to fall into; it worked all right; and when the holes were full, put coal oil and coal tar on them. Robins, wrens, turkeys and chickens will destroy them; I think any insect-eating bird will eat them.

MR. F. C. HALMAN, Muncy, Lycoming county, Pa.:

The army worms were in this county and in this section, appearing about July 20th and remaining ten days. They moved from field to field and attacked the oats and corn, destroying about two-thirds of the oats crop; the corn was not hurt much. I would estimate my loss to be $125. No means were taken for their destruction; they came so suddenly that the damage was done before we were aware of them. I have not noticed any birds destroying them. The loss to the township is probably $5,000.

MR. HARVEY SMITH, Muncy Station, Lycoming county, Pa.:

The army worms were in this county and in this section, appearing July 15th and remained two weeks. They moved from one field to another. They attacked oats and corn, destroying one-fourth of the crops. My loss is $50. No means were taken for their destruction. Sparrows destroy them.

MR. CHARLES BRELSFORD, Williamsport, Lycoming county, Pa.:

The army worms made their appearance in this county and were in my township (Eldred), appearing about July first, but disappeared in a few days. They moved from one field to another when not prevented. Timothy and rye seemed to be damaged the most as far as I can learn; in one or two places they destroyed a small field of rye. In one place where they attacked a field of timothy the farmer plowed a furrow about twenty rods and turned his poultry on them; he says they destroyed a large number of the worms.

MR. JAMES ECROYD, Muncy, Lycoming county, Pa.:

The army worms were in this county and in this section, appearing June 15th and remained two weeks. I do not think they moved, they appeared to hatch in the field. Oats was the only crop they damaged and it was so slight it would be hard to make an estimate.

except in two or three instances, when perhaps ten per cent. would cover the loss. The loss to the township will probably be $30, and to the county $400. Nothing was done to destroy them.

MR. CHARLES L. LITTLE, Bryan Mill, Lycoming county, Pa.:

The army worms were in this county and there were a few in this section, appearing from July 25th to August 3d, and remained until the oats were cut attacking the oats crop here, destroying about one-fourth of the field attacked. My individual loss would probably reach $5. No means were taken for their destruction; the crow seemed to be very busy working on something in the fields where the worms were.

MR. PETER RUDER, Hughesville, Lycoming county, Pa.:

The army worms made their appearance in this county and in this section early in July and remained about one month. They did not move from field to field. Attacked the oats, destroying very little, as they were few in numbers here. There was nothing done to destroy them.

MR. B. G. GROFF, Elizabethtown, Lancaster county, Pa.:

The army worm appeared in this county on July 16th. I did not see them move, but know of them being five miles northeast of us before they appeared here. They attacked the oats; were a little late for the early oats which were nearly or already ripe, but green spots were soon destroyed; some fields were three-fourths destroyed; some one-half; some one-fourth and others only damaged a trifle. My loss is $50, and that of the township probably $10,000. No means were taken for their destruction.

MR. J. W. McLANAHAN, Elizabethtown, Lancaster county, Pa.:

The army worms were in this county and in my section, appearing about July 10th and remained about seventeen days moving from one field to another. They attacked wheat, oats and corn destroying wheat slightly; oats from one-half to a total crop; corn in several instances and then only slightly. The loss in Mt. Joy township alone is probably $20,000.

No means were taken for their destruction; few farmers knew of their presence until they had attacked the growing crops. I have not noticed insects, birds or other enemies destroy them; I have asked many farmers and others and they say that they have not seen insects destroy them.

To give you an idea of the destruction I will relate a few instances. One farmer who estimated that his yield would have been 1,800 bushels of oats, thrashed last week and had 278 bushels as his crop. Another thrashed three four-horse loads and got seven bushels; another sold his crop as straw. Many will not go to the expense of

thrashing their crops, while a few in the section named report half a yield. Wheat was almost free from attack on account of being mostly harvested when the pests appeared, and only a few report that corn has been tttacked.

MR. JOHN H. EPPLER, Elizabethtown, Lancaster county, Pa.:

We had the army worms in three or four different localities in the county appearing from July 15th to 20th and remained twelve days. They attacked the oats and in some instances destroying one-half the crop and others the total crop was destroyed; chickens will eat them.

MR. E. D. SHANK, Elizabethtown, Lancaster county, Pa.:

The army worms made their appearance in this county and in this section. They appeared the middle of July and remained two weeks. They seemed to move. They attacked the oats, destroying probably one-half the crop. The money loss is about $100. No means were taken for their destruction, but I should use paris green after this.

MR. E. K. BATES, Conewago, Lancaster county, Pa:

The army worm made its appearance in this county and in this section, appearing about July first and remained two weeks. It did not move from field to field and attacked the oats only, destroying two-thirds of the crop. My loss is $90 or 600 bushels of oats. I did nothing to destroy them as it was my first experience with them.

MR. WM. F. HAMILTON, Elizabethtown, Lancaster county, Pa.:

The army worm made its appearance in this county and in this section, appearing July 10th and remained about twenty days. They attacked the oats destroying about one-tenth the crop. The loss to the township will probably be $600. No means were taken for their destruction.

MR. R. R. RITTER, Allentown, Lehigh county, Pa.:

The army worms were in this county and were in South Whitehall township, appearing from the first to the fifteenth of July, and remained three weeks. They attacked mostly oats; at some places corn and grass destroying about one-third of the crop in my township; my loss is $120; the loss to the township will probably be ten thousand bushels and to the county fifty thousand bushels. No means were taken to destroy them that I know of. Sparrows, wrens, robins and nearly all kinds of birds will destroy them.

MR. DANIEL F. FINK, Allentown, Lehigh county, Pa.:

The army worms made their appearance in this county and were in this section. They appeared about July 20th and remained two weeks attacking oats, corn and grass destroying the entire oats crop

where they made their appearance. My loss is about one hundred bushels. Nothing was done to destroy them except digging ditches and cutting a swath around the field. I think the best destroyer, from my experience, is to head them off as quickly as you can.

MR. JEREMIAH ROTH, Allentown, Lehigh county, Pa.:

The army worms were in this county and in my section, appearing about July first and remained a month. They moved from one field to another and attacked wheat, grass, oats and corn. The proportionate loss to crops is wheat about ten per cent., grass ten per cent., corn ten per cent., and oats about twenty-five per cent. I would estimate my loss to be about $200, and the loss to the township to be $4,000, and to the county $30,000.

No means were taken to destroy them except in small patches. The English Sparrow and robin destroy them.

MR. W. B. K. JOHNSON, Allentown, Lehigh county, Pa.:

The army worms made their appearance in some localities in this county and were in small numbers a half mile from my grounds. They were first noticed about July first and remained about three weeks or a month. They were not particular what they attacked, oats, corn, grass, etc., destroying some fields very little and others totally. Reports say that on one farm 600 bushels of oats were destroyed; others eight to ten acres of potatoes, etc.; the loss to the township will probably be $500.

No means were taken for their destruction. Not having daily observance myself cannot tell, but am told robins, sparrows and other birds destroy them.

MR. R. A. BUTZ, Coplay, Lehigh county, Pa.:

The army worms were in this county and in this section, and were first noticed about July first, and remained two weeks. They attacked the oats, destroying about one-third of the crop. My loss is about $150. No means were taken for their destruction. I have noticed the English Sparrow destroying them.

MR. C. S. WEISS, Allentown, Lehigh county, Pa.:

The army worms were in this county and in my section, appearing July 8th or 10th, and remained about ten days, attacking oats and clover, destroying on some farms all the oats; on others from one fourth to one-half. Some dug ditches and others cut their oats to save it; the dutch sparrow destroys them.

MR. WESLEY DEIHL, Strawberry Ridge, Montour county, Pa.:

The army worms were in this county and in this section, appearing July 10th, and remained twenty-five days. They moved on several farms. They attacked the oats, grass and in a few instances corn. Oats appeared to be their favorite food, destroying about

Cat Bird Destroying Army Worms.

eight per cent. of it; two per cent. of the grass; corn very slightly damaged, probably one per cent. My individual loss would not exceed $5, while some of my neighbors lost nearly their whole crop of oats. The loss to the township will probably be $400, and to the county, $5,000. Nothing was done to destroy them in this locality.

MR. DANIEL HOTTENSTEIN, Limestoneville, Montour county, Pa.:

The army worms made their appearance in this county and in this section, appearing about July first and remained four weeks. They moved from field to field, attacking oats, corn and timothy. The loss to each crop is very little; they eat the leaves off the timothy and corn and the grain of the oats. My money loss is only a few dollars ($5). No means were taken for their destruction. I have not observed any birds, insects or other enemies destroy them.

MR. CALVIN W. DERR, Limestoneville, Montour county, Pa.:

The army worms were in this county and in my section, appearing the latter part of June and moved from one field to another. They attacked the oats by cutting off the leaves and grain; corn by eating leaves and some say the tassel, also timothy by killing it entirely. Corn was destroyed very little; oats about one-fourth. I would estimate my loss to be $100. Turkeys and chickens destroyed them.

MR. DANIEL COTNER, Grovania, Montour county, Pa.:

The army worms were in this county and in my section, appearing sometime in June, and remained about a month and attacked the oats. The loss is about fifty bushels; my damage is $72.50. We did nothing to destroy them, but the ducks destroyed some.

MR. J. W. ALLISON, Mercer, Mercer county, Pa.:

The army worms made their appearance in my section about July 15th and remained two weeks, attacking oats and corn. Blackbirds gathered in large numbers and soon destroyed them.

MR. P. L. McCARTNEY, Clark's Mills, Mercer county, Pa.:

The army worms were in this county, but not in this section. The English Sparrow and crow destroy the worms.

MR. R. C. SHOEMAKER, Jarrettown, Montgomery county, Pa.:

The army worms appeared in several townships in the county and were in my section. They were first noticed June 26th and remained only a few days moving in a direct course going northwest. They destroyed one and a half acres of sweet corn in less than forty-eight hours; one-half acre one foot high; went through 20,000 cabbages (adjoining the corn) but did not hurt it; next 4,000 poles of lima beans, did but little harm; next a field too old to harm, but

eat out all the timothy, leaving some clover; next came twelve acres of potatoes, but I do not see that they hurt them. They destroyed all corn that was above ground and all the grass that was in the fence rows as if it had been burnt. My loss is about $400, unless the timothy springs up from the root, then it would not be so much. The loss to the township will probably be $1,500. Cannot say what the loss to the county will be. We used paris green, but had no effect on the worms.

MR. JAMES W. THOMAS, King of Prussia, Montgomery county, Pa.:

From facts in my possession the army worms appeared in Lower Merion township about ten miles from this place. They attacked the oats lying in swaths and completely destroyed it. They entered the lawn of Wendell P. Bowman, and completely ate the grass as far as they went. A heavy roller was used to stop their progress.

MR. GEORGE D. PENNYPACKER, Lewistown, Mifflin county, Pa.:

The army worms made their appearance in this county and were in my section. I first noticed them the 15th of July and I do not think they moved from one field to another. The oats was the only crop we heard of them attacking excepting in one case where corn was growing close by we saw the blades riddled by something we supposed to be the army worm, but did not find the worm anywhere but in the oats. A very small proportion of the crop was destroyed.

MR. R. A. NAGINEY, Milroy, Mifflin county, Pa.:

The army worms were in this county and in my section, appearing the latter part of July in our locality and remained from three to four weeks and attacked the oats. I am unable to say what the loss is as they were not seen on any farms joining me; but evidently there was something in my neighbors field that destroyed three or four acres. Nothing was done for their destruction as far as I know; I did not observe any birds or insects destroy them.

MR. WILLIAM B. BRATTON, Shank's Run, Mifflin county, Pa.:

The army worms were in this county and in my section, appearing July 13th, and they worked altogether on the oats crop in this section, destroying on an average about ten per cent. of the crop; the loss to the township is probably $500. We did not do anything to destroy them as they got in their work pretty well before we discovered them. The English sparrows and crows are all I have noticed destroying them.

MR. W. H. TAYLOR, Reedsville, Mifflin county, Pa.:

The army worm made its appearance in this county and in my section about July 20th, and remained until the oats was harvested. I could not tell if they moved; could not see many through the day, must have done their work at night. They attacked the oats and

the loss in some fields will be as high as twenty per cent.; others less; I have one twelve acre field that I think the loss would be eight or ten bushels per acre and at present prices of oats would amount to $19 or $20. The loss to the township will be $500. No means were taken for their destruction.

MR. D. H. HERTZLER, Mattawanna, Mifflin county, Pa.:

The army worms were in this county and in my section, appearing in July and remained two months. They first attacked the oats and then went to the corn, destroying fifty per cent. of oats and twenty per cent. of corn. I plowed around the fields and when they fell into the ditch straw was put in and then burned; these were the means used to destroy them with good success. The loss to the township will probably be $400, and to the county $4,000.

MR. ADAM LEPPARD, McVeytown, Mifflin county, Pa.:

The army worms were in this county and in my section, making their appearance about the middle of July and remained a week. They attacked oats and barley. I have not heard of them moving. Personally I do not know much about them, as I have had but few of them, doing little harm; one of my neighbors complains of suffering a good deal from them, but the loss in this locality is very little. I heard of one farmer using paris green, which was successful.

MR. O. D. BUSH, East Smethport, McKean county, Pa.:

The army worms were in this county and in this section. They appeared about July first and are here yet. They moved from one field to another, attacking the oats, corn, rye, wheat, hay and peas. Destroyed about one-fourth of the crop.

Some plowed ditches and dragged a log in them while they were marching to destroy them, but with not very good success. Robins, English sparrows, groundbirds and nearly all common birds destroy them.

MR. LINCOLN GALLUP, Smethport, McKean county, Pa.:

The army worms appeared in this county and in this section on July 8th and remained about thirty days. They moved to a certain extent; worked out in every direction from the fields first attacked. They attacked the oats and corn mostly, but were in the grass and clover to some extent, especially the seeding in oats, which is entirely eaten up, about three-fourths of the oats and two-thirds of the corn were destroyed. The loss is from $500 to $600. Plowing furrows were tried for their destruction, but was only successful where water could be kept in the ditch.

English sparrows, swallows, blackbirds, turkeys and chickens destroy them.

MR. R. DENNIS, Eldred, McKean county, Pa. :

The army worms made their appearance in this county and there were a few on my farm. They appeared the first of July and remained three weeks. They attacked mostly oats, but were on a few pieces of corn, destroying about one-fourth of the oats. Some plowed ditches around their fields and saved their crops. The crow, English Sparrow and chickens will destroy them. The loss to the township will probably be from $300 to $400, and to the county $1,000.

MR. JOHN W. BUSH East Smethport. McKean county, Pa.:

The army worms were in this county and in this section. They appeared July first and remained three weeks, moving from one field to another. They attacked oats, corn and grass destroying one-third the corn; oats totally and grass but slightly damaged. I cut some grain around the field and plowed a furrow around it and then drew logs through until they were mostly destroyed. It was a partial success. English sparrows, crows and poultry destroy them.

MR. E. J. WRIGHT, Eldred, McKean county, Pa.:

The army worms made their appearance in this county and in this section, appearing July sixth and remained three weeks. They moved from field to field and attacked the oats, rye, corn, millet and grass, destroying the rye entire and one-third of the other crops. My loss is $150. I used lime and paris green to destroy them with good results. Blackbirds, crows, chickens and turkeys destroy them. The loss to the county will probably be $50,000.

MR. H. A. CROASDALE, Delaware Water Gap, Monroe county, Pa.:

The army worms made their appearance in this county and in this section about the first of July and remained three or four weeks. They attacked the rye and oats, more particularly the latter, working in patches that had lodged badly while yet quite green. The loss to the crop is about five per cent. Hard to tell my loss, other causes working with them perhaps $40. No means were taken for their destruction; they did not move about much and the patches were scattered, making it difficult to do anything. I am not positive, but think the crow blackbird destroyed them; I noticed a large flock of blackbirds flying from the field and observed they had worms in their mouths.

MR. A. S. SHIMER, Redington, Northampton county, Pa.:

The army worms were in this county and in this section. They appeared July 24th, and did not remain long. They attacked oat and corn destroying some fields totally and others partly. The loss

Lawn Showing Rear of the House

to the township will probably be $1,000, and to the county $3,000. Some made furrows around the field with slight success.

MR. J. C. SHIMER, Martin's Creek, Northampton county, Pa.:

The army worms made their appearance in this county and in this section. They appeared July 15th or 20th, and moved from one field to another. They attacked wheat, oats and corn damaging wheat and rye slightly; some oats the stalks were stripped entirely, others slightly. The loss to the township is probably fifty per cent. No means were taken for their destruction. The spider appears to be an enemy of theirs.

MR. MILTON H. KOEHLER, Bethlehem, Northampton county, Pa.:

The army worms made their appearance in this county and in this section about the middle of July and remained two weeks. They did not move from field to field that I noticed, but attacked the oats mostly and at some places corn and clover. The loss on grass and clover is small, but some oats were not worth cutting. We have a small township and I believe the probable loss will be $200. No means were taken for their destruction. There were lots of crows in my field and I believe they destroyed them. I cannot give you the name of any particular destroyer.

MR. B. B. McCLURE, Bath, Northampton county, Pa.:

The army worms made their appearance in this county and were in this section. They appeared July first and remained until August first, moving from one field to another. They attacked chiefly oats; in some instances they hurt the clover in wheat and also attacked corn fields, but not generally; the oats crop was probably one-half destroyed. The loss to the township may be $1,500 and to the county $2,000.

No means were taken for their destruction, excepting when they began to work on corn, paris green applied put them to sleep.

MR. W. S. ACHENBACH, Bath, Northampton county, Pa.:

The army worms were in my county and in my section, appearing June 20th and remained four weeks. They attacked oats and clover and corn to some extent. The loss is two-thirds of the oats and all the clover that they struck. I would estimate my money loss to be $200. I am not able to give loss to the township very correctly; may reach $4,000. There were no means taken for their destruction.

MR. C. L. PECK, Coudersport, Potter ocunty, Pa.:

The army worms made their appearance in this county and were in this section. They appeared June 25th and remained about five weeks. They moved some but not generally. They attacked grass, oats and corn principally. The loss to the crop is less than one-

twentieth. The loss to the township is $1,000, or more, and to the county $20,000.

MR. L. C. KILBOURNE, Sunderlinville, Potter county, Pa.:

The army worms were in this county and in this section, appearing July 10th and remained about a month attacking oats, barley, corn and rye, destroying two-thirds of the crop; my loss is $125; the loss to the township is probably $1,200.

MR. ALLEN FRINK, Hebron, Potter county, Pa.:

The army worms made their apearance in this county and in my section about the first of July and remained about five weeks. They moved from field to field, attacking wheat and rye first, afterwards oats and corn, destroying from one-fourth to one-half of each crop. I would estimate my loss at $50. Plowing a furrow around the fields was the only means taken for their destruction. The success was not very good. Birds, ducks and all kind of poultry destroy them.

MR. T. J. LENT, Coundersport, Potter county, Pa.:

The army worms were in this county and in this section, appearing July 12th and remained three weeks. They moved from one field to another. They were on my corn first and then the oats, destroying three-fourths of the oats; they left the corn before they damaged it. I put lime on my corn; the crow and what we call sparrows destroyed many of them. When they disappeared I looked under stones and found a lot of them with a shell formed over them and in about three weeks they hatched out into miller.

MR. W. A. GARDNER, Andrew's Settlement, Potter county, Pa.:

The army worms were in this county and in my section, appearing in July and remained from fourteen to twenty days and attacked spring rye, oats, corn, millet and grass, destroying some crops totally; others partially. Ditching, rolling, burning with straw saturated, with kerosene, paris green mixed with air-slacked lime and salt were used to destroy them without success. The worms are now mostly in the ground undergoing transformation; what the second development may be, we are at present unable to say; the loss is large here and with many much suffering must follow, unless public help is given.

MR. MILO LYMAN, Roulette, Potter county, Pa.:

The army worms were in my county and were in my section, appearing June 25th and remained six weeks. They moved from field to field, attacking hay and oats first, but would consume almost any green thing. About one-twentieth of the hay and one-third of the oats crop were destroyed. I would estimate my money loss to be not more than $75. The probable loss to the township is $3,000, and to

the county $1,200. No means were taken for their destruction; they have nearly all disappeared.

MR. JOHN MARSCH, Greentown, Pike county, Pa.:

The army worms were in this county and were within two miles of me. They appeared about July first and remained one month. They attacked the rye first, then the young grass in the rye, then went into oats fields, but I only heard of two corn fields attacked. I saw two oats fields that they were in and it looked as if the half was destroyed.

No means were taken for their destruction.

MR. A. J. KIMBLE, Paupac, Pike county, Pa.:

The army worms made their appearance in this county, but were not in this section. They appeared about the first of July and I understand they moved from one field to another. They attacked the oats and young grass; they ate the new grass out of the oats and destroyed all the new stock of oats where they worked. Some used coal oil; I heard of some plowing furrows around the fields and letting them fill up then turning another furrow on the worms. I do not know what success they had.

MR. GEORGE A. KNEALING, Shohola, Pike county, Pa.:

The army worm made its appearance in this county and in this section. They appeared July first and did not remain very long. They attacked oats and corn, destroying the stalk of corn and the leaves and kernel of the oats. No means were taken for their destruction, nor did I observe any birds destroying them.

MR. AARON LEWIS, Hillsgrove, Sullivan county, Pa.:

The army worms were in this county and in my section, appearing July first; remained three weeks and moved from field to field, attacking rye, oats, corn, grass, wheat to some extent; I cannot estimate the loss; some pieces of oats were entirely destroyed while others were not touched; they did not do much damage to me; probably $4 would cover my loss; the loss to the township will probably be $85. Furrows were plowed around the field which checked their advance to some extent.

MR. VALENTINE ROHL, Dushore, Sullivan county, Pa.:

The army worms made their appearance in this county, but were not in my section. They appeared about July 16th and remained from ten to fourteen days. They attacked oats mostly; sometimes buckwheat and corn destroying from one-third to one-half the oats; corn and buckwheat they did not damage much. The loss to the township will probably be $60, and to the county $250. No means were taken for their destruction; sometimes the grain was mowed green and they worked on it as long as it remained green. They

were first seen at an old stump and some stone piles. They do their work in the night and lay under stones, sticks or any place that is cool during the day. We had a few rainy days and they have nearly all distppeared.

MR. C. F. HUNSINGER, Colley, Sullivan county, Pa.:

The army worms made their appearance in this county, but were not in my section; they were first noticed about July 10th and remained four weeks, moving from field to field. They attacked oats, corn and grass destroying some crops entirely, about one-sixteenth of the oats and corn and grass much less. The loss to the county will probably be $1,000. Ditches were dug and when filled were burned with straw and oil; some were poisoned by slug shot and some were killed by paris green; some by coal tar and several other remedies were tried and all were somewhat successful.

MR. L. B. SPEAKER, Hillsgrove, Sullivan county, Pa.:

The army worm was in this county to a serious extent, also in this section, appearing the middle of July and remained five weeks. They moved from one field to another, attacking rye, oats, corn and new seeded timothy and clover and destroyed one-third the oats; one-fourth the rye; all new seeded grass. My loss is about $100. Plowing furrows, digging ditches between fields of rye and oats were tried with but little effect. The English Sparrow ate them. The loss to the township will probably be $2,000.

MR. SAMUEL KILMER, Millview, Sullivan county, Pa.:

The army worms were in this county and in my section, appearing about the 20th of July and remained two weeks. They attacked mostly oats; where they did the greatest amount of damage; they also assailed corn, but did not do it much harm; they seemed to have a perfect aversion to buckwheat, clover and potatoes. From one-fifth to four-fifths of the oats were destroyed and about the same proportion of timothy; my loss is less than many of my neighbors, I should think about $60; the loss to the township will probably be $500. I did nothing to destroy them, but in some parts of this township many were destroyed by making holes into which they fell and then were killed. There are no sparrows in this vicinity; other birds do not seem to make any headway in their destruction; in my immediate neighborhood about the time the worms had reached their full growth skunks attacked them; on my farm they (the skunks) have rooted or dug a large part of five acres of ground over making it look as if pigs were there and not a sign of a worm or cocoon or moth can be found; in an adjoining township chickens which ate the worms soon sickened and died.

Rye Field Attacked by Army Worm

MR. JOHN W. RODGERS, Forksville, Sullivan county, Pa.:

The army worm made its appearance in this county and in this section on July 15th, remaining about twelve days. They attacked the oats mostly, also corn and grass and in most cases where they attacked the oats they destroyed it totally. Plowing ditches was tried for their destruction with pretty good success. Meadow larks and English sparrows destroy them. The loss to the township will probably be $300, and to the county $1,000.

MR. S. C. FOX, Somerset, Somerset county, Pa.:

The army worms were in this county and in this section, appearing the first of July and remained about three weeks. They moved to some extent. They attacked the oats. No means were taken to destroy them.

MR. GEORGE A. STEIN, Orwigsburg, Schuylkill county, Pa.:

The army worms made their appearance in this county and in this section. They appeared the second week in July and remained about ten days. They moved from one crop to the other, attacking oats, corn and cabbage and destroying about three-fourths of the oats and corn and cabbage slightly damaged. My loss is $30. The loss to the township will probably be $250. They cut the balance of the oats for food; and the worms disappeared.

MR. JAMES A. HEFFNER, Friedensburg, Schuylkill county, Pa.:

The army worms were in this county and in this section, appearing July first and remained about thirty days. They moved from one field to another, attacking wheat, rye, oats and corn and destroying wheat and rye probably five per cent.; oats fifteen per cent.; in one instance an entire field of twenty acres was destroyed; the loss to the township will probably be $500, and to the county from $5,000 to $8,000. Some mixed paris green with wheat bran and scattered it around their corn fields with good success. I have not observed any birds or insects destroy them.

MR. DANIEL YEICK, Freidensburg, Schuylkill county, Pa.:

The army worms were in this county and there were a few about one-fourth mile from here. They appeared the first of July and remained a month and attacked the oats, destroying one-eighth of the crop; the loss to the township will probably be $600 and to the county $8,000. My neighbors took wheat bran and paris green and sowed it around the fields with good results. I did not observe any birds or insects destroy them.

MR. E. W. ZEIGLER, Freidensburg, Schuylkill county, Pa.:

The army worms were in this county and in my section, appearing June 20th and remained about forty days, attacking the oats and destroying five per cent. of the crop; my loss is about $20; the loss

to the township is probably $150, and to the county $2,000. No means were taken for their destruction; turkeys will eat them.

MR. JOHN R. GROH, Pine Grove, Schuylkill county, Pa.:

The army worms made their appearance in this county about the middle of July. My money loss is about $25. I think birds and crows eat them.

MR. W. S. SOPHIA, Harford, Susquehanna county, Pa.:

The army worms were in my section, appearing about July 10th and remained one week. In some instances they moved from field to field and attacked the oats and corn, destroying some fields one-half; some less and some sustained no injury. My loss is probably not more than ten per cent. on five acres of oats.

I did nothing to destroy them; some dug ditches and burned them. They were successful when the worms moved from field to field. I have observed birds, insects and other enemies destroy them. The common brown sparrow, cat bird and robin were very plentiful on the fields, especially early in the mornings and destroyed a great many.

MR. J. C. MORSE, Lakeside, Susquehanna county, Pa.:

The army worms made their appearance in many parts of the county and were general in our section. They appeared July first and remained about three weeks. Oats was the crop damaged the most; corn and grass especially the seeding of this spring was attacked. On an average fifty per cent. of the crops were destroyed; some fields were completely destroyed, others not so much. Salt, kerosene, paris green and trenches were the means tried for their destruction and were not at all satisfactory. There seemed some parasite that destroyed the worms; I do not know the name, it appeared to be something that absorbed the juices of the worm, especially noticed in the pupa state.

MR. R. S. SEARLE, Montrose, Susquehanna county, Pa.:

The army worms made their appearance in this county and in my section about June 15th and remained a month, attacking oats, rye, corn and new seeding which they generally destroyed. It is hard to tell what proportion of crops were destroyed, say: corn, two per cent.; oats, fifty per cent.; rye, ten per cent.; seeding, ninety per cent. I would estimate my money loss to be from $50 to $75, and the loss to the township probably $500. I did not take any means to destroy them; some fought them, but of no avail; they had their day and were gone. Crows and I think skunks worked on them; crows on my place, I think, kept them down.

We have had the army worm here before, although not so general; I think the very warm weather in April and May and absence of

frosts and heavy rains brought out the first brood, which was not noticed, but the second brood, of course, was large.

MR. O. C. GALLOWAY, Susquehanna, Susquehanna county, Pa.:

The army worms made their appearance in this county and in this section on July first and remained three weeks. On some farms they moved from one field to another. They attacked mostly oats and some corn that stood near the oats field, destroying some of the oats fields entirely; some one-third and corn entirely.

Digging ditches and making holes in them was tried for their destruction, but was not very successful. Skunks were observed to destroy them; no other enemies noticed.

MR. C. L. HOYT, Osceola, Tioga county, Pa.:

The army worms were nearly all over this county and were in this section. They were first noticed July 10th, then they were an inch long and about July 25th began to find the imago. They moved quite often, but not always. They attacked oats, timothy, spring wheat, corn, barley and tobacco; the latter was not liked. In a few places they ate potatoes, new seeding was wiped out wherever the army worm was plenty. Oats and spring wheat were destroyed from one-half to all; timothy, one-fourth; corn, five per cent. to all. My loss is $100. Some plowed furrows; some cut their grain; others rolled their ground and some cut a swath and rolled that. The furrow did the most good, but the crops were only partly saved. Turkeys, chickens, guinea hen, crow, and English Sparrow kill them. A lady bought a chicken for cooking and found the crop crammed with army worms and many holes in the crop as if the worms had eaten through. The chicken was not eaten. The loss to the township will probably be $3,000, and to the county $20,000.

MR. GEORGE W. DICKINSON, Keeneyville, Tioga county, Pa.:

The army worms were in this county and section, appearing the first of July and remained from two to four weeks. Did not attack all sections at the same time. They moved from field to field, attacking wheat, rye, oats, barley and in some places meadows; also corn, especially fodder corn, destroying in some fields only a small part; in other fields one-fourth; in others one-half or more; in others the crop was nearly lost.

To cut off travel furrows were plowed in which they were killed; in large fields swaths were cut through the fields and furrows plowed; part of the crop was saved. Nearly all the birds, from the crow down to the sparrow, destroy them to some extent.

MR. M. V. JACKSON, East Charleston, Tioga county, Pa.:

The army worms made their appearance in this county and were in this section. They appeared about the first of July and remained

from three to four weeks. They attacked oats, corn, barley and new seeding, destroying about one-third of the oats and a very small per cent. of the other crops, except seeding.

The loss to the township will probably be $2,500.

A few used rollers and plowed ditches to protect their crops with little success. Crows and chickens and some say English sparrows destroy them.

MR. A. B. DOANE, Little Marsh, Tioga county, Pa.:

The army worms appeared in this county and in this section. They appeared about June 15th and remained forty days. In some localities they did move. They attacked wheat, rye, barley, oats, timothy and corn; they soon left the corn. As near as I can estimate the loss to the crops will be ten per cent. The loss on my farm is $10. Some plowed furrows when they were crossing from one field to another, the worms would drop in and die; others used land rollers and kerosene oil, paris green on gardens all with good results; destroyed large numbers of them.

The English sparrows, chickens, turkeys and crows will feed on them; I have made inquiries about them and have observed them myself; the crows will gather in large numbers in the field where the worms are at work you will see them busy and will not find a worm where they are.

The loss to the township will probably be $500 and to the county $10,000.

MR. C. E. GRAHAM, Lorenton, Tioga county, Pa.:

The army worm made its appearance in this section about July first and remained four weeks. In some places they moved from one field to another, attacking the oats and timothy, destroying about one-half the crop in places and in others the loss was slight. My loss is about $50. Kerosene was tried for their destruction with poor success; but the crow and other small birds, domestic fowls and the ant will kill them.

The loss to the township will probably be $2,500.

MR. H. C. CRAWFORD, Cooperstown, Venango county, Pa.:

The army worms were in this county and in my section appearing the 25th of July and remained ten days. They did not move, seemed to disappear after partially destroying the oats; I should think about half the crop was destroyed; my loss is about $100. No means were taken for their destruction.

MR. PORTER PHIPPS, Kennerdell, Venango county, Pa.:

The army worms made their appearance in this county, but were not in my section. They appeared from the middle of July to the last of the month. From the only reports that I have they appeared

in a twenty-five acre field of oats of Miller & Sibley five miles north of Franklin and cleaned the blades and grain; but have no reports of their moving further; think the heavy rains destroyed them.

MR. P. H. ILOFF, Honesdale, Wayne county, Pa.:

The army worm was found in every township more or less in the county and was in my section. They appeared July first and remained three weeks attacking oats, corn, rye and hay, destroying from one one-hundredth to entire crop; they did not appear to do any damage on my farm; the probable loss to the township will be $500 and to the county from $8,000 to $10,000.

Where they were leaving a field a V shaped trap made of boards with the upper edge painted and a pan of water placed at the opening into which the worms were swept also a clean furrow plowed and when the worms got in a small log dragged through were the only successful means employed here to destroy them. Black wasps, black spiders, pissmires and a bird commonly called chippee destroyed them.

MR. A. S. MARKS, Starrucca, Wayne county, Pa.:

The army worms were in this county and in my section, appearing the 12th of July and remained four weeks. They attacked oats grass and corn, destroying the oats fields entire that they were in; the damage on corn and hay was slight; the loss to the township is $800 and to the county $20,000. Some plowed ditches and others used salt to destroy them. I have not observed any birds destroy them; read of a fly that lays an egg on their backs that hatches and destroys them; it resembles a house fly.

MR. L. A. SMITH, Calkins, Wayne county, Pa.:

The army worms were in this county and in this section, appearing about July first and remained four weeks. They attacked oats and corn. Some put kerosene on them and burned them where they were gathered together; others cut furrows around fields of grain and one man ran a roller in the ditch crushing them. I could not say what the success was as they left right away and have not returned. Some claim a fly lays an egg on the back of their heads and when hatched out eats into the worm causing its death. It is smaller than a house fly.

MR. J. E. ROCHE, South Canaan, Wayne county, Pa.:

The army worms were in this county but not general, but were in my section. They appeared July first and remained two or three weeks and attacked the corn first, then oats and in some instances destroying the entire crop; two-thirds would be a fair average; fortunately I escaped almost entirely; the loss to the county will

probably be from $15,000 to $20,000, and to the township $1,000. Ditches were plowed or dug with holes at intervals; emulsions of kerosene oil, hard soap and water and coal-tar were used to destroy them. On the whole the efforts were not very successful. The common blackbird feeds voraciously on them; a small black fly resembling the house fly, seemed to be numerous where these worms were at work; can't say as to their objects.

MR. H. MAHAN, Leander, Warren county, Pa.:

The army worms were in this county and in my section, appearing the middle of July and remained two weeks attacking all corn, barley and oats. I think my loss is slight, but I can tell better when I thrash twenty acres of barley, eight of oats and ten of corn. No means were taken to destroy them to my knowledge; some furrows were plowed to head them off; I have not observed them, but some say a little fly stings them and destroys the worm; I do not know the name of it.

MR. M. W. BOVEE, Goodwell Hill, Warren county, Pa.:

The army worms were in this county and in my section making their apearance from July 10th to 12th, and remained one week, attacking grass and timothy destroying about two-thirds of the crops. My loss is $25. No means were taken for their destruction; the worms here did not seem to like oats; a small patch self sown in a field of grass destroyed was not damaged; the worms in nearly every case were in fields near barns and in grass that was very heavy; light grass was not troubled.

MR. J. H. BRADLEY, Ackley Station, Warren county, Pa.:

The army worms were in this county and in my section, appearing about July first and remained four weeks moving from field to field, attacking oats, corn and millet, destroying about one-third of the oats and one-eighth of the millet and corn. My loss is about $50, and that of the township $1,000. Nothing was done for their destruction; after four weeks they went into the ground and in about two weeks were hatching millers.

MR. H. P. LOOMIS, Lemon, Wyoming county, Pa.:

The army worms were in this county and in this section, being on my farm. They appeared the middle of July and remained ten days, attacking chiefly the oats; sometimes corn, destroying one-fifth my oats; the ground was covered with oats at harvest cut off by the worms; my loss is about $20; the loss to the township is probably $200 to $300, and to the county from $3,000 to $5,000. Crickets and pissmires destroy them; on turning over stones to look for the worms I would often find where something had made havoc among the worms and after a little observation discovered it to be the above named insects.

ACTUAL SIZE

THE DESTRUCTION OF CEREALS AND GRASSES.

Little or nothing was heard of the army worm in this State until about July when letters, telegrams and boxes of specimens began to come from all sections to the Agricultural Experiment Station and the Department of Agriculture. A circular letter explaining to farmers the best means to be adopted to combat the army worms was sent broadcast throughout the Commonwealth. This circular letter prepared under the direction of Deputy Secretary of Agriculture, Prof. John Hamilton, was also mailed to all newspaper editors of the State, who kindly published the same. Owing to this fact, farmers in many sections of the Commonwealth were enabled to adopt means to successfully combat the attacks of the hungry and destructive insects.

The writer, through this medium, desires to extend his most cordial thanks to the press of Pennsylvania for having so promptly and generously presented this important matter to the public. If the newspapers had not responded as they did, we feel confident the loss through the army worms' ravages would have been much greater than they were.

The army worms include in their menu quite a wide range of food-plants, but they seem to prefer the grains and grasses. Timothy, oats, corn, rye and barley received their particular attention, and in some localities entire fields were destroyed.

Lawn grass in some sections was eagerly devoured, and many beautiful lawns were laid bare. The damage in this direction, according to our correspondents, was particularly noticeable in Luzerne, Lackawanna and Cambria counties. They have also been known to eat onions, peas, beans and other garden crops. Cranberry crops have been greatly damaged by them, and in one instance 'an army of the worms, in passing through a strawberry patch, devoured both the leaves of the plant and the unripe fruit.' Experiments have shown that in confinement the worms will live, thrive, and undergo their transformations when fed exclusively upon either the garden poppy, beet, lettuce, cabbage, raspberry, onion, parsnip radish, carrots or pea. They refused to feed, however, on bean, cotton, grape and hemlock.

Ordinarily clover is not eaten by the worms; it is said that "a timothy field is often eaten to the ground, leaving the clover scattered through it standing." In 1880, however, a remarkable exception occurred in New Jersey where in some localities clover-eating by the worms was the rule and not the exception.

Fruit growers have little to fear from this pest. In one case, as mentioned above, a strawberry bed was injured by an army of the

worms, and there is but one record of their having eaten the leaves of fruit trees."

The several illustrations accompanying this report showing the character of damage done to cereals and grasses are reproduced from photographs taken especially for this article by Prof. Geo. C. Watson, of the Pennsylvania State College, on the Experimental Farm at the College where much damage was done by the hosts of army worms.

BIRDS AND MAMMALS VS. ARMY WORMS.

A very careful series of investigations were made at the State College, and in other parts of the State to ascertain what species of birds and mammals fed on the army worms, and it was ascertained that the great majority of birds fed upon them with great eagerness. The skunk, in the nighttime, visited the grain fields and consumed immense numbers of the larvae. The frolicsome little chip-munk devoured them. The insectivorous toad also fed ravenously on the crawling pests.

SWALLOWS AND FLYCATCHERS.

Swallows and flycatchers, which subsist almost wholly on winged insects did not, according to our observations, disturb the army worms. Woodpeckers, other than the common flicker, did not, so far as the writer was able to observe, feed upon the worms.

CROWS AND BLACKBIRDS.

The crows and blackbirds, the latter in good-sized flocks, were to be seen in almost every field where the worms were abundant and they destroyed immense numbers of the pests.

ROBINS, CAT-BIRDS AND THRUSHES.

These sweet-voiced and familiar birds visited fields and lawns and lived exclusively on the juicy army worms. A catbird shown in one of the illustrations was photographed by Prof. Watson on a corn stalk in the act of catching army worms which were devouring the corn blades.

MEADOW LARKS AND BLUE BIRDS.

Meadow larks and blue birds were quite plentiful on the State College farm and it was ascertained that both of these species consumed great numbers of the army worms. The inquisitive and saucy little house wren as well as the well-known "chippy" (illustrated with fiery ground beetle calosoma calidium) fed with great relish on the worms.

KILLDEER AND SAND-PIPER.

Several specimens of killdeer and the spotted sandpiper or "tilt-up" were shot and in all their stomachs were found remains of army worms.

Blue Bird—1. Male; 2 Female; 3. Young.

Flicker — Male — Female

THE SPARROW TRIBE.

Numerous numbers of this extensive family were found to feed extensively on the army worm. In fact the stomachs of some of these birds were discovered on dissection to be literally gorged with the remains of the larvae.

THE ENGLISH SPARROW AND ARMY WORM.

As many farmers claimed that English Sparrows were doing great execution to the army worms I made postmortem dissections of the viscera of one hundred and seventeen of these birds taken in fields and lawns in different parts of the State where the army worms were present and of this large number I found in but twelve the remains of army worms. This convinced me that the majority of my informants had mistaken some of the other sparrows or immature cow blackbirds for English sparrows.

WHAT SOME DISSECTIONS SHOWED.

While conducting our investigations in Centre county we met a number of intelligent farmers who assured us that sparrows (meaning English sparrows) were devouring the worms by the wholesale.

In order to know to a certainty that these little naturalized foreigners were of some benefit, I, at the suggestion of a gentleman who assured me they were destroying army worms in his wheat stubble and barley fields, visited these places and shot 39 English sparrows, 18 cow blackbirds, the latter in immature plumage, and several other species of the sparrow family. The post-mortem dissections of these birds showed that 36 of the English sparrows had eaten nothing but vegetable food, mainly wheat and barley kernels; and as to the other three sparrows, one had eaten two army worms, another two, and the third when picked up had one in its mouth. The stomach contents of 18 of the cow blackbirds showed that 17 had fed on army worms, seven of which were found in one bird. Five grasshopper sparrows taken in the wheat stubble had all eaten the larvae, five being taken from one bird. Two Savanna sparrows, which breed quite plentifully about the State College, had six army worms in their stomachs, and five of seven Bay-winged or Vesper sparrows were found to have seventeen of the larvae in their viscera. A single crow blackbird had its stomach distended with thirteen of the juicy and dark-colored worms.

As numerous correspondents expressed the opinion that English sparrows had a marked fondness for army worms, I obtained from Warren, Chester, Luzerne, Montgomery, Dauphin, Cambria, Union and Lackawanna counties seventy-eight additional birds of this species, all of which were shot in fields or lawns where the army worms were numerous. In this lot only nine birds were discovered, after careful search, to have fed on the destructive larvae.

In the investigations which were made of the English Sparrow in connection with the pestiferous Army Worm the writer was very materially aided by Messrs. Geo. P. Friant, taxidermist of Scranton, Pa., and Mr. C. M. Busch, of Washington, D. C., to whom through this medium, he desires to extend his most cordial thanks for numerous specimens they so kindly assisted him to secure.

THE COMMON CROW.

The viscera of twenty-three crows, old and young, which were captured in different counties of the State, and in localities where army worms were abundant, were in many instances, found to be gorged with the remains of these larvae. Crows also ate the pupae. I noticed crows and blackbirds, especially the Common Crow Blackbird, to be quite numerous in nearly all fields where the crawling hosts were abundant, and these dark-colored and greatly abused birds, by their constant warfare on the worms, did much to keep in check the damage to cereal and other crops. The crows were generally to be observed singly or in pairs, sometimes in parties of four, five or seven individuals, but the blackbirds were often noticed in good-sized flocks. One flock of blackbirds numbered fully seventy-five individuals and they all seemed to be intently engaged for a considerable time in the morning and evening, as well as at intervals in midday destroying the worms. A crow would eat a handful of the worms at a single meal; and the number which a single bird would devour in a day was immense.

Several farmers, whose premises I visited when investigating with Prof. G. C. Watson, of Pennsylvania State College, the ravages of the army worm, expressed great surprise when they were informed that crows and blackbirds fed almost wholly on the voracious insect-pests which were devastating the oats, barley, corn and grass fields. When specimens of the birds were shot and the contents of their stomachs exposed, they admitted that these birds were "not as bad as it was commonly supposed."

HE LOVES EGGS AND CHICKS.

The crows' fondness for eggs and young of domestic fowls as well as his penchant for despoiling the nests of numerous wild birds of eggs and young is well known; then again the crow visits the corn field in the spring time and in the autumn he often does considerable damage. These carnivorous tastes and grain-eating habits of the crow have caused, it seems, a great many of our farmers to place Mr. Crow under ban. The Crow Blackbird, like the Common Crow, destroys the eggs and young of different species of beneficial birds which nest in orchards, parks and gardens, and he also often, like the crow, visits the corn field or cherry tree. However, if farmers

1/3

AMERICAN CROW.

would take the trouble in the spring when crows and their bright-eyed relatives, the blackbirds, are at work in corn fields to carefully investigate they would find no doubt, as the writer has, that these birds are not there for the purpose of destroying corn, but to save it from crawling foes which are hidden beneath the soil.

THEY DEVOUR CUTWORMS AND "BUGS."

Reader, if you doubt this statement take the trouble, sometime in the spring, when you see crows and blackbirds in a corn field, when the corn is an inch or two above the ground, to shoot some of the birds, open their stomachs, and the chances are ten to one you will discover that these "corn-pulling" birds have nothing but "cut worms," other larvae and beetles in their food receptacles.

SOMETIMES TAKE CORN.

The crow undoubtedly, at times, particularly in the fall when the farmer is slow about taking corn in from the fields, sometimes does considerable damage. In the spring this bird also occasionally does a good deal of mischief in corn fields. This same statement may likewise be made concerning the blackbird. However, notwithstanding the fact that both species of birds just mentioned destroy more or less corn, the great amount of good they do by destroying innumerable insect foes which prey, constantly during the summer season, on grain, fruit and garden crops, is, according to my judgment, considerably in excess of the money loss occasioned by losses incurred from casual predatory visits these omnivorous birds make to the growing or ripened corn.

A BAD HABIT.

If it was not for the bad habit which the Crow has of destroying eggs and young of both poultry and wild birds, and the same is true of the Crow Blackbird which has acquired quite an appetite for eggs and nestlings of different species of small wild birds, there could be no possible reason for doubt in the mind of any naturalist about both of these well known species being far more beneficial than harmful to the farmer and fruitgrower. Sportsmen also view the Crow and Crow Blackbird, especially the former, in an unfavorable light, because they will often destroy the eggs and sometimes the young of game birds (particularly grouse and quail) meadowlarks, etc. Along the salt water marshes of the Atlantic ocean, when collecting specimens with my genial and gifted friend, the naturalist, Mr. C. M. Busch, we have observed the crow pillaging the nests of terns and Mud-hens or Clapper Rails as ornithologists call these skulking and vociferous birds which in September are often

killed in great numbers on the meadows about Atlantic City and elsewhere along the Atlantic coast southward from New Jersey.

THE SCREECH OWL.

The little Screech Owl which is quite common in some parts of the State, but rather scarce in other sections, on account of unwise and wasteful bounty laws, and millinery taxidermists who hunt these mice and insect eating birds for the purpose of decorating ladies hats, preyed eagerly on the Army Worm. In the viscera of fourteen of these owls, which were captured in Centre, Lackawanna, Chester, Union and Dauphin counties, and examined by Mr. Geo. P. Friant or the writer, it was found that twelve or all but two of the birds had army worms in their stomachs. In the stomach of one owl, a young male, I found remains of twenty-two of the larvae; with fragments of beetles and a small mass of fine hair, evidently that of a field mouse. This series of examinations convinced me that the Screech Owl had scored another strong point in its favor, and one which if known to farmers who destroy these little owls when found about their premises under the mistaken idea that they kill young poultry would surely cause them to stay the hand which was, at all times, ready to slay these noisy yet interesting, red and gray-coated feathered benefactors, which in the silent hours of night, when the husbandman is at rest from the toils of the day, visit fields and buildings to destroy insidious foes "singly insignificant but collectively a scourge."

MR. OWL WAS CONSIDERATE.

The two owls which had no army worms in their stomachs were secured in the town of Lewisburg, where army worms were not present in any great numbers. One of this pair of owls had the remains of an English Sparrow in its stomach. The viscera of the other owl was empty and as the two birds were taken in the same yard and the female owl had feasted on the sparrow it is but reasonable to infer that Mr. Owl found food scarce and he very properly allowed his lady-love to eat the little feathered prize fighter which she did, feathers and all.

THE SPARROW HAWK.

This diminutive representative of the hawk family was another example of the Birds of Prey which was found, through our careful field investigations, to gain much of its dietary from the crawling and curled up bodies of voracious army worms which infested the cultivated lands.

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SCREECH OWL.

1/2

SPARROW HAWK.

DOES NOT CATCH CHICKENS.

The beautiful little Sparrow Hawk, the smallest of the family, Falconidae, is unfortunately by many misinformed farmers and sportsmen believed to be only capable of devouring the young of poultry and game birds. This erroneous and, I am sorry to say, rather popular idea, causes annually the destruction of great numbers of these eminently beneficial birds when they come about the habitations of men to catch mice, grasshoppers and beetles. Sparrow Hawks are destroyed by farmers and hunters because the average citizen seems to be unable to distinguish this species from other small-sized hawks, viz: the Cooper's, Sharp-shinned and Pigeon, birds which are all detrimental to poultry and game as well as to many kinds of small wild song and insectivorous birds. The State of Pennsylvania which annually expends large sums of money for publishing documents for free distribution could not in my judgment make a wiser outlay for the benefit of this and rising generations than by publishing a document, properly illustrated, which will deal in a popular way with hawks, owls, and other species of birds and mammals concerning which so many wrong impressions are entertained by the masses.

PUBLISH WHAT THE PEOPLE WANT.

Documents on the subject of birds, fish, trees, etc., which the State has, in former years, issued by special acts of Assembly, have been well received by the citizens of the Commonwealth, as was evidenced by the fact that the demand for these publications was greatly in excess of the number authorized by law.

DON'T WASTE THE COUNTY FUNDS.

Ignorance of the true economic value of hawks and owls, collectively considered, and certain beneficial mammals, has caused the expenditure in this State of probably nearly a quarter of a million of dollars in the past twenty-five years in the way of bounties. Under the Act of 1885, in about eighteen months nearly $150,000 (estimated) were paid in premiums for "noxious birds and animals" by the various counties (other than Philadelphia and Allegheny). Of this sum probably not less than $85,000 (estimated) were expended for hawks and owls. Screech Owls and Sparrow Hawks were slain by hundreds under the Act of 1885 for the fifty cents which the head of each beneficial but luckless bird was worth to the scalp hunter.

IGNORANCE AND FRAUD.

While there is little doubt that an examination of the counties'

bounty records will show, when all are added in a grand total, that eighty-five or more thousands of dollars were paid for "hawk and owl heads" it is not a fact that all the heads presented for premiums were those of raptorial birds. It is known that ignorance and fraud caused a great outlay from the local exchequers, and that officials in different localities in the State paid out money to scalp hunters for heads of chickens, turkeys, pheasants, sea gulls, guineas, cuckoos, robins, nighthawks, and even the miserable, little worthless English Sparrow, believing the same to be the heads of poultry-destroying hawks and owls. Red squirrels', and chip-munks' and ferrets' heads answered in some sections for the "heads and ears" of weasels and minks, because, of course, the local officials did not know one animal from another. An old buffalo hide, a mule skin and the pelt of a very young colt enabled, with skillful manipulation, a party of scalp hunters to draw from one county it is said over $3,000 in premiums before exposure came about.

Such popular ignorance about the common birds and other wild animals which have their homes in forests, fields, mountains and gardens should not exist in this age of advanced civilization and era of higher education.

POPULAR EDUCATION ESSENTIAL.

As a servant of the people I propose to prepare reports, bulletins and papers which will, I think if given wide circulation as they should have, tend to correct the unjust prejudice which maintains against many animals, clothed in either feathers or fur, which in reality are among the husbandman's most valued adjuncts in keeping in subjection the insidious insect and other troublesome pests.

WHAT DISSECTION SHOWED.

The viscera of seventeen of these little hawks, adults and young, captured in grain and grass fields or along highways, in sections where army worms were destroying crops at a ruinous rate, showed that not less than seven of the hawks had only these larvae in them; five of the birds had army worms and other insects; three had eaten grasshoppers and small mammals (mice most likely) and a few "worms;" the stomachs of the remaining two hawks were destitute of food materials.

This series of examinations convinced me that the Sparrow Hawk prefers to subsist on insects or mice and that when such food-materials are readily obtained he will not bother to hunt small birds which were plentiful in every place where we obtained the hawks.

SKUNK

THE SKUNK.

This familiar animal generally hides in some dark retreat during the daylight although occasionally on cloudy days he is seen abroad and he also hunts in the twilight. The Skunk technically known as Mephitis mephitica and a form or sub-species called the Carolinian Skunk, (Mephitis mephitica elongata) as defined by Mr. Bangs are common in Pennsylvania. Many thousands of these animals are annually killed in this State for the fur trade. Indeed, the long and heavy coat of this mammal is so valuable in the fur markets that Skunk farms are conducted on an extensive and profitable basis in New York, Ohio and other States.

RANKS FIRST AS AN INSECT EATER.

Of all our mammals this species is probably the most valuable to the farmer and fruit grower. The insect-eating habits of this nocturnal prowler are so generally known to the farmers of the hop-growing districts of the Empire State that I am informed local laws have been enacted for the protection of the much abused and persecuted Skunk, which Dr. C. H. Merriam very truly says: is "pre-eminently an insect eater, he destroys more beetles, grasshoppers and the like than all our other mammals together, and in addition to these devours vast numbers of mice."

HE IS IN BAD REPUTE.

Through numerous reports received at the Department of Agriculture from farmers, poulterers and sportsmen in Pennsylvania it is quite evident that the odoriferous Skunk is not regarded with much favor, in fact, but a small number of our correspondents appear to know that he possesses any inclination to eat insects and destructive larvae. The general impression appears to be that this slow moving animal reaches the acme of his bliss when he can gain an entrance to a hen-coop and devour a chicken or suck eggs, and it matters but little how old the latter may be.

SPORTSMEN SPEAK ILL OF HIM.

A number of sportsmen who spend considerable time every year in the woods and fields give the Skunk a record blacker than the pelt of the most marketable "polecat" (a common name for the Skunk in many parts of Pennsylvania), to be found within the Keystone boundaries.

With few exceptions the testimony from sportsmen is that the main thing the Skunk lives for in this region is to devour the eggs of grouse, wild turkeys, quail and other birds which nest on or

close to the ground. Such opinions concerning the Skunk are wrong, yet, they are, unfortunately, quite generally entertained by a large class of our citizens, who have become unjustly prejudiced against this harmless mammal and destroy him and his family, when in reality these animals are of great benefit on the farm where detrimental insects and sleek-coated rodents are almost continually at work preying on the crops.

WHAT AN EMINENT NATURALIST WRITES.

Concerning the food habits of the Skunk, Dr. C. Hart Merriam, of Washington, D. C., a gentleman who is universally regarded as one of the most eminent and reliable Economic Zoologists in America, says : "He preys upon mice, salamanders, frogs, and the eggs of birds that nest on, or within reach from the ground.

"At times he eats carrion, and if he chances to stumble upon a hen's nest the eggs are liable to suffer; and once in a while he acquires the evil habit of robbing the hen-roost. Still, as a rule, Skunks are not addicted to this vice, and it is with them very much as it is with dogs and cats; for every now and then a dog will get into the habit of killing sheep, and a cat of killing chickens and sucking eggs, and yet we do not wage warfare of extermination against them, collectively, on account of the sins of a few of their number.

HE IS OF GREAT VALUE TO HOP-GROWERS.

"He is of the greatest practical value to the hop-grower, for he frequents the hop-yard with great regularity, and greedily devours the insect pests that, from their numbers and destructiveness, always injure and sometimes ruin the crop. * * * Indeed, the benefit that accrues to the farmer from the occupancy of his premises by a family of these useful animals can hardly be over-estimated. They are large eaters and subsist almost exclusively upon his greatest enemies—mice and insects.

"Of the truth of this assertion he may easily convince himself by merely taking the trouble to examine any bit of 'Skunk sign' that he happens to come across; for in the summer season, their dejections consist wholly of the indigestible chitenous coverings of beetles, grasshoppers and other insects."—The Vertebrates of the Adirondack Region, N. E. New York, Dec., 1883.

These statements from the facile pen of the genial and able Merriam, together with such information as any one can readily gain by devoting a little study to the Skunk in his native haunts should cause the thoughtful farmer's boy to hesitate before destroying every Skunk and its family which he may come across.

MIDNIGHT PROWLERS.

Of course we know it's very trying on a "fellow's feelins" when he goes out "as the shades of night are falling" in a nice clean buggy and with a well-kept trotter, to run over a clumsy skunk when he is hurrying to see his best girl, but always bear in mind it might be worse if that best girl was with you. Yet under such circumstances the Skunk should not be too severely censured; the chances are he would suffer more from the unexpected meeting than you would.

Remember also all the skunk-tribe should not be persecuted because you may on one occasion have been unfortunate enough to have gotten a good supply of perfume when "a wooing you would go."

DEVOURED THE ARMY WORMS.

Skunks proved themselves in different parts of the State where army worms were abundant to be a most efficient aid to the farmer in assisting him in the war of extermination. The skunks would visit fields of oats, corn, grass, etc., and turn over clods of earth, stones or search around the roots of the cereals for the larvae and pupae which they consumed by the hundreds. One gentleman says, he saw at least twenty of these animals industriously at work in a small patch of corn which had been visited by the army worms. He attributed the saving of his corn to the hungry skunks which he stated devoured in a couple of days all the worms.

WHAT A SULLIVAN COUNTY FARMER SAW.

Mr. Samuel Kilmer, a prominent farmer of Millview, Sullivan county, fully appreciates the value of the skunk as an insect destroyer. In relation to its taste for army worms he writes as follows: "In my immediate neighborhood about the time the worms had reached their full growth, skunks attacked them: on my farm they (the skunks) have rooted or dug a large part of five (5) acres of ground over, making it look as if pigs were there; and as a result not a sign of a worm or cocoon or moth can be found."

WHAT OTHER FARMERS NOTED.

Mr. H. G. Wright, of East Canton, Bradford county, writes, that in his locality where army worms were abundant in July, skunks visited the fields infested with the crawling hosts and "devoured them in large quantities." Mr. A. S. Rockwell, of Troy, in western Bradford county, also makes record of the great usefulness of the skunk as a destroyer of the army worms. Mr. O. C. Galloway, of Susquehanna, Pa., says: "Skunks were often observed destroying

the worms, and as these animals fed with great relish on both the larvae and pupae they necessarily destroyed large numbers of the pests."

HUNTED WORMS BY DAYLIGHT.

Another correspondent states that in his locality the skunks were apparently so anxious to regale themselves on the juicy worms that they came from their holes and harboring places in neighboring rocky hillsides, in the daytime to seek out the larvae from under stones, clods and cut grain.

The stomach contents of three skunks examined by the writer consisted of insects remains, principally beetles and army worms.

THE DOUBLE-NECKED BABCOCK BOTTLE FOR TESTING SKIM MILK AND BUTTERMILK.

BY MILTON E. McDONNELL.

CONCLUSIONS.

1. Results obtained on the same sample of milk are comparatively very uniform.

2. All results are slightly low on account of a small quantity of fat remaining in suspension and it is probable that a minute quantity of fat is also dissolved by the acid.

3. The inaccuracy varies slightly for different samples of milk.

4. While the results are never absolutely correct, they are sufficiently accurate for all practical purposes in creamery work, and the ease with which different operators can secure uniform results by the method makes it valuable.

DETAILS OF THE TESTS.

In the following table are given the results of ten tests, each of twelve different samples of skim milk and mixtures of the same with water and with whole milk:

Nos. 1, 5 and 9 were samples of normal skim milk from the Station Creamery. A second series of samples was prepared from these by diluting a portion of each one with an equal volume of water and numbering them respectively 2, 6 and 10. A third series was prepared by adding 15 c. c. of whole milk containing 4.2 per cent. of fat to 285 c. c. of Nos. 1, 5 and 9. This amount of whole milk theoretically increased the amount of fat in the samples to which it was added .21 per cent. This series of samples was numbered 3, 6 and 11 respectively.

In the fourth series of samples the amount of fat in the first series was increased .42 per cent. by adding 30 c. c. of whole milk to 270 c. c. of each of the samples 1, 5 and 10. The difference between these different samples is indicated in the table.

These samples which we have just described were preserved with corrosive sublimate and a series of ten tests made on them. The tests were made at different times so as to avoid as far as possible any common error that might enter.

Tests of Skim Milk.

Double-necked Babcock Test Bottle.

Sample No.	Description of Sample.	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
1	Normal skim milk,	.05	.03	.05	.01	.04	.04	.03	.025	.05	.03
2	No. one and water 1:1, ...	.02	.01	.01	.01	.01	.01	.01	.02	.01	.01
3	Fat content of No. one increased .21 per cent., . .	.23	.20	.24	.20	.18	.23	.22	.22	.25	.23
4	Fat content of No. one increased .42 per cent., . .	.40	.45	.40	.38	.44	.44	.44	.46	.42	.43
5	Normal skim milk,	.01	.005	.02	.01	.005	.01	.015	.02	.01	.01
6	No. five and water 1:1, ...	.00t	.00t	.00	00t	.00t	.00t	.02	.01	.01	.005
7	Fat content of No. five increased .21 per cent. . .	.18	.17	.21	.16	.18	.21	.20	.19	.20	.22
8	Fat content of No. five increased .42 per cent., . .	.35	.32	.35	.34	.37	.38	.37	.40	.35	.38
9	Normal skim milk,	.00	.005	.01	.00t	.00t	.005	.005	.01	.00t	.00t
10	No. nine and water 1:1.	.00	.00	.00	.00t	.00t	.00	.00	00	.00	.01
11	Fat content of No. nine increased .21 per cent., . .	.15	.16	.18	.15	.18	.18	.15	.16	.15	.15
12	Fat content of No. nine increased .42 per cent , . .	.33	.33	.36	.30	.37	.35	.37	.38	.35	.37

An examination of these results shows that we are justified in concluding that the method is uniform for the same sample of milk. The average of the greatest variations in each of the ten tests of each sample is .04 per cent. The greatest variation on any one sample is .08 per cent. and this variation occurs on only two samples. The samples on which this variation occurred contained about five-tenths per cent. fat. These variations are relatively very small considering the simplicity of the method and the difficulty of securing an accurate fat determination on a sample of skim milk.

The above table also shows that the results are slightly too low. In the first place there is probably no separator that skims milk absolutely clean, yet in the experiment nine tests did not show a trace of fat and seventeen showed less than .01 per cent. In the second place samples 3, 7 and 11 contained .21 per cent.more fat than 1, 5 and 9, and more than .21 per cent. more than 2, 6 and 10. The average differences as shown by the test taking the samples in their respective numerical order are .182, .196, .179, .167, .158, .156, .158 and .160. In no case is the difference .21 per cent.; so that the results are evidently low on these samples. The variation is different, showing that the error is different for different samples.

Samples 4, 9 and 12 contain .21 per cent. more fat than 1, 5 and 9 respectively, and .42 per cent. more than 3, 7 and 11. The results on these samples also show that the results are low and variable, but

we will not discuss them because the column of fat had to be moved in the calibrated tube before the per cent. could be read and this introduced a chance for error. The bottles were not found to be very satisfactory on samples containing from four to five tenths per cent. of fat because of the necessity of raising the column in the tube in order to read it, and there is always danger of breaking the column of fat by doing this. All breaks made in this way cause an error. The bottles would be better if they were so constructed that the fat would rise to the proper place in the tube while whirling. It would appear that the manufacturers could overcome this objection by increasing the length of the large tube.

The results given in the next table confirm the above conclusions and the fat contents of the samples is confirmed by gravimetric chemical analysis according to the official method.

A sample of skim milk was taken and the fat content found by gravimetric analysis to be .16 per cent. One volume of this sample was diluted to two volumes with water and theoretically contained one-half as much fat as the first or .08 per cent. Another sample was prepared by adding 3 c. c. of milk to 300 c. c. of the normal skim milk and thus increasing the per cent. of fat approximately .05 or from .16 to .21 per cent. In the same way the fat content of the next sample was increased to .26; a fifth sample to .32, and the sixth to .37 per cent. By referring to the table the manner in which every sample was prepared will become more clear. These samples were all analyzed by the official method. The double necked Babcock bottles gave results .01 of a per cent. lower than the calculated amount, and .08 of a per cent. lower than those actually obtained by gravimetric analysis.

Number of sample.	Description of sample.	Theoretical per cent. of fat calculation on the basis of 0.16 per cent. in No. 20811.	Per cent. of food actually found by extraction with ether.	Per cent. of fat by double-necked Babcock test bottle.
20810	Water and skim milk 1:1,.	.10	.10	.03
20811	Skim milk, April 14, 1896,.	.16	.16	.06
20812	300 c.c. of No. 20811, and 3 c.c. of 5.3 per cent. whole milk mixed, ...	21	.19	.11
20813	300 c.c. of No. 20811, and 6 c.c. of 5.3 per cent. whole milk mixed, ...	26	23	.16
20814	300 c.c. of No. 20811, and 9 c.c. of 5.3 per cent. whole milk mixed, ...	32	28	.21
20816	300 c.c. of No. 20811, and 12 c.c. of 5.3 per cent. whole milk mixed, ...	.37	.33	.25

The accompanying results by Mr. Farrington, of the Wisconsin Experiment Station, show conclusively that results obtained by this method are lower than those obtained by gravimetric analysis. All of the results published by him in which both methods were used are given in the table and can be studied by any one who cares to do so.

By taking the mean of all results we find the results by the Babcock method to be .056 per cent. lower than those obtained by gravimetric analysis.

Test of Skim Milk.*

Creamery No.	Name of separator.	Per cent. of fat.	
		Double-necked Babcock test bottle.	Gravimetric analysis.
1	Alpha No. 1	.05—.08	.12—.15
3	Alpha No. 1	.08—.08	.13—.13
6	Alpha No. 1	.05—.05	.06—.06
7	Alpha No. 1	.03—.05	.07—.10
8	Alpha No. 1	.05—.08	.13— 14
14	Alpha No. 1	.05—.08	.15
50	Alpha No. 1	.23—.34	.31.—32
4	Alpha No. 2	.08—.08	.08.—12
50	Alpha No. 2	.20—.23	.26—.25
9	Standard De Laval	.20—.10	.14—.13
9	Standard De Laval	.20—.12	.19—.15
15	Standard De Laval	.10— 10	.20
2	Danish Western	.20—.25 / .25—.35	.23—.26
7	Danish Western	.05—.05	.10—.10
7	Danish Western	.05—.05	.15—.17
11	Danish Western	.20—.25	.22—.21
3	Reid's improved Dan.	.15—.15	.18—.23
5	Reid's improved Dan.	.15— 15	.20— 23
51	Russian Standard	.70—.72	.69—.70
10	United States No. 1	.15—.15	.21—.20
10	United States No. 1	.15— 15	.16—.18
12	United States No. 1	.08—.08	.18—.19
16	United States No. 1	.15—.15	.24
18	United States No. 1	.15—.12	.27
18	United States No. 1	.25—.25	.34
14	Empire No 20	.10—.12	.26

*Farrington: Bul. 54, Wisconsin Experiment Station.

A careful study of all of the above data seems to fully justify the conclusions enumerated at the beginning of this article.

METEOROLOGY OF 1896.

By W. S. SWEETSER.

The climatic conditions of a locality are a large factor in the culture of its crops, but as yet very little is known concerning the relations which differences in climatic conditions between either locations or seasons bear to the raising of crops except in a general way. Therefore it is the purpose of this station to keep from year to year a tabulated record of those conditions under which the field investigations are carried on, and to determine, if possible, what effect any pronounced change in the weather has upon the crop under investigation.

The work of the past year has been merely a continuation of the work of the preceding years, including the observations usually called for by the United States Weather Bureau upon atmospheric conditions, and also observations upon soil temperature at various depths, and upon the daily duration of sunshine.

The results of the observations upon atmospheric conditions have been reported monthly to the United States Weather Bureau and to the Pennsylvania State Weather Service.

ATMOSPHERIC METEOROLOGY.

The latitude of the Station is 40° 55′ N. and the longitude 77° 51′ W. The altitude of the mercury cistern of the barometer is 1,217 feet above sea level. The thermometer shelter is sixty feet northwest of the Station office and sixteen feet above ground.

The apparatus used consists of a standard mercurial barometer reading to .001 inch; dry and wet bulb, and maximum and minimum thermometers by Green; standard eight-inch rain gauge, standing two feet above ground level, an anemometer and a weather vane. A snow gauge completes the list. This consists of a galvanized iron cylinder made of such a diameter that one inch of rain or melted snow increases the weight one kilogram.

15—22—96

Meteorological Summary—Monthly Means, etc.

	January.	February.	March.	April.	May.	June.
Atmospheric Pressure in Inches.						
Monthly mean.	30.174	29.906	30.018	30.103	29.988	29.957
Highest,	30.579	30.612	30.619	30.536	30.318	30.256
Date,	15.	17.	14.	8.	7.	25.
Lowest,	29.648	28.948	29.275	29.705	29.691	29.557
Date,	24.	6.	11.	21.	28.	9.
Monthly range.	.931	1.764	1.344	.831	.627	.699
Temperature in Degrees Fahrenheit.						
Monthly mean.	26.7	28.3	28.7	52.0	64.7	65.6
Maximum,	46	52	61	88	90	86
Date,	30.	28.	30.	17.	9.	20.
Mean maximum.	32.7	36.0	37.2	61.7	73.9	75.7
Minimum,	1	—6	3	21	47	42
Date,	4.	17.	24.	3.	8.	2.
Mean minimum,	20.6	20.5	20.1	42.3	55.4	55.5
Monthly range.	45	58	58	67	43	44
Daily Range.						
Greatest,	29	36	33	34	39	31
Date,	3.	16.	24.	13.	9.	2.30.
Least,	4	5	6	8	5	8
Date,	24.25.	4.	11.	4.7.	2.	24.
Mean.	12.0	15.5	17.1	19.4	18.5	20.2
Humidity.						
Mean relative humidity, per cent.,	90.2	89.2	87.2	77.1	72.0	80.5
Mean dew point, degrees Fahrenheit,	22.2	23.1	23.7	42.8	53.9	57.7
Precipitation.						
Total in inches,	1.36	3.66	2.82	1.47	1.37	5.02
Snowfall, in inches,	3.00	12.00	17.95			
Greatest daily precipitation,	1.02	1.02	.95	.50	.43	.74
Date,	24.	6.	19.	21.	31.	7.
Number of days on which .01 inch or more fell,	5	10	12	9	11	14
Cloudiness.						
Mean percentage,	70	68	62	63	59	57
Number of days on which cloudiness averaged 80 per cent. or more,	13	14	14	13	11	10

Wind.						
Prevailing direction,	W	W	W	W	W,	W,
Wind followed by rain,	SW, E, SE, NW, W, S, SW, SE,	W, E, N, SW NE, SW, W,	S, W, SW, W, NE, S,	E, SW, S, W, SW, E, S,	S, W, SW, NW, E.	SE, W, W, NW, NE, SE, E.
Wind followed by fair weather,	14	28	27	18	12	10
Maximum velocity in miles per hour,	6, 26,	6,	2,	4,	11,	4, 22,
Date,	265	365	435	430	190	225
Greatest movement in miles,	4	7,	2,	4,	11,	11,
Date,	2,030	3,880	3,895	3,905	2,110	1,360
Monthly movement in miles,						
Miscellaneous Data.						
Dates of thunder storms,				20		8, 16, 21.
Dates of hail,	2, 5, 6, 12, 16, 17, 18, 28, 29, 30,	18, 27, 28.	18, 24.	8, 9, 23.		
Dates of frost,			4,		17.	
Dates of aurora,	2	22, 24	21 26, 27,	23.		
Dates of halos, solar,						
Dates of halos, lunar,						

Meteorological Summary—Monthly Means—Continued.

	July.	August.	September.	October.	November.	December.
Atmospheric Pressure in Inches						
Monthly mean,	29.997	30.014	30.028	30.059	30.168	30.179
Highest,	30.336	30.341	30.296	30.477	30.649	30.861
Date,	18.	29.	23.	9.	23.	28.
Lowest,	29.688	29.773	29.573	29.637	29.514	29.675
Date,	24.	2.	29.	23.	5.	9.
Monthly range,	0.648	0.568	0.723	0.840	1.135	1.186
Temperature in Degrees Fahrenheit.						
Monthly mean,	71.1	69.9	62.1	47.2	46.3	30.8
Maximum,	89	93	91	72	71	60
Date,	27.	9.	11.	29.	18.	13.
Mean maximum,	80.2	79.3	72.9	55.6	55.7	38.3
Minimum,	50	45	35	26	21	5
Date,	18.	28.	23.	26.	30.	28.
Mean minimum,	61.9	60.5	51.3	38.7	36.9	23.3
Monthly range,	39	48	56	46	50	55
Daily Range.						
Greatest,	36	26	35	30	30	27
Date,	1.	5, 15.	10.	26.	15.	13.
Least,	10	8	8	6	7	5
Date,	7.	13.	29.	13.	4.	22.
Mean.	18.3	18.8	21.6	16.9	18.8	15.0
Humidity.						
Mean relative humidity, per cent.,	81.4	71.7	81.1	84.5	81.3	85.0
Mean dew point, degrees Fahrenheit,	64.2	61.0	53.8	40.1	37.6	25.0
Precipitation.						
Total in inches,	5.56	1.56	5.02	3.29	3.11	1.04
Snowfall, in inches,					Trace.	2.5
Greatest daily precipitation,	1.09	.45	2.40	1.31	1.43	.41
Date,	30.	12.	30.	12.	5.	8.
Number of days on which .01 inch or more of rainfall,	14	11	10	10	10	6
Cloudiness.						
Mean percentage,	56	46	52	6.2	6.2	6.2
Number of days on which cloudiness averaged 80 per cent. or more,	11	9	8	14	8	13
Wind.						
Prevailing direction,	W.	W.	W.	W.	W.	W.

Wind followed by rain,	SW, N, S, W,		S, SW, W,		N, S, SE, E, W,		NE, W, SW,		E, S, W,		SW, E, W,	
Wind followed by fair weather,	SW, S, N, NW,		W, NW, N.		W, NE,		W, NW, N, SW,		W, SW, NW,		W, NW, S,	
Maximum velocity in miles per hour,		8		10		15		12		25		15
Date,	2, 3, 25, 31,		19		29,		1, 7		13,		23.	
Greatest movement in miles,		160		165		165		155		225		300
Date,	25,		27		23,		7		14,		19	
Monthly movement in miles,		1 200		1,010		1,490		1,180		2 075		2, 105
Miscellaneous Data.												
Dates of thunder storms,	27, 28, 30.				19,							
Dates of hail,												
Dates of frost,												
Dates of aurora,					24, 25.		3, 9, 10 11, 19, 22, 23, 25, 26, 28,		7, 10, 23,		1, 2, 3, 4, 5, 8, 12, 13, 16, 20, 28, 29,	
Dates of halos, solar,							10.				3,	
Dates of halos, lunar,			18,								20,	
									26.		10, 12, 19.	

SOIL TEMPERATURE.

The observations upon the soil at various depths are a continuation of those made for the six years preceding. They were made at 8 A. M., 2 P. M., and 8 P. M., the same as in the two preceding years. The thermometers, which were made by Green, were set at the surface, and at depths of one, three, six, twelve and twenty-four inches in a trench, the earth afterwards being carefully tamped about the bulbs so as to secure a good contact. The trench was then filled to ground level. The surrounding vegetation was kept down. The soil is a moderately dark, compact loam for a depth of about seven inches and below that a stiff clay. The thrice-a-day records will be found in the appendix, but a summary of the most important data for the year will be presented in the following tables:

Summary of Soil Temperature for 1896.

	January		February		March.		April		May		June	
Atmosphere.												
Monthly mean,			26.7		28.3		28.7		52.0		64.7		65.6
Monthly maximum,			46		52		61		88		90		86
Monthly minimum,			1		—6		3		21		47		42
Mean daily range,			12		15.5		17.1		19.4		18.5		20.2
Greatest daily range,			29		36		33		34		39		31
Least daily range,			4		5		6		8		5		8
Surface.													
Monthly mean,			27.4		30.4		31.1		50.5		63.9		68.1
Extremes:													
Monthly maximum,			44		47		57		89		84		86
Date,	29, 30.			1.		30.		18.		17.		3, 21.	
Monthly minimum,			8		12		14		27		52		58
Date,	4, 5			17.		5.		3.		1, 2		12.	
Mean maximum,			30.5		33.0		35.5		58.0		71.5		76.6
Mean minimum			23.8		28.0		27.1		46.2		59.7		64.0
Range.													
Monthly,			36.0		35.0		43.0		62		32		28
Mean daily,			8.23		5.00		8.39		11.73		11.68		12.30
Greatest daily,			21		17		26		23		20		21
Date,	16,			27,		5,		13, 18.		27,		3, 16.	
Least daily,			0		0		0		1		1		1
Date,	19.			3, 4, 5, 9, 10, 11,		11, 12, 16, 19.		17.		23,		7.	
One Inch.													
Monthly mean,			29.2		30.4		39.7		47.7		62.8		67.3
Extremes:													
Monthly maximum			33		43		49.5		58		79.5		79
Date,	30.			1.		31,		17, 18.		14.		21.	
Monthly minimum,			19		18.5		19		30		51.5		56.5
Date,	5, 6.			17.		5.		4.		2.		1, 2.	
Mean maximum,			30.3		31.3		32.2		50.4		66.3		71.3
Mean minimum			27.6		29.4		29.1		44.2		58.7		63.0
Range.													
Monthly,			14		24.5		30.5		17		28.0		22.5
Mean daily,			2.76		1.66		3.06		6.30		7.48		8.07
Greatest daily,			6.5		11		17.5		18		16.5		19
Date,	18,			1,		31,		23,		14,		3,	
Least daily,			0		0		0		0.5		1.5		2
Date	20, 24, 26.			19 days.		8 days		3, 7.		2.		13.	

Summary of Soil Temperature for 1896.—Continued.

	January.	February.	March.	April.	May	June.
Three Inches.						
Monthly mean	30.9	30.9	31.1	47.0	62.6	67.7
Extremes:						
Monthly maximum	33.5	32.5	34	63.5	69.5	76
Date,	1,	1, 2, 15.	31.	18,	17,	22.
Monthly minimum	25	23.5	23.5	32	52	56.5
Date,	6.	18.	5.	3, 4, 5, 6,	4.	2.
Mean maximum	31.2	31.2	31.5	48.5	64.3	70.0
Mean minimum	30.3	30.3	30.4	43.9	58.8	63.2
Range:						
Monthly	8.5	9.0	10.5	31.5	17.5	19.5
Mean daily	0.95	0.93	1.05	4.50	5.48	6.83
Greatest daily	4.5	5.5	7	11.5	10.5	12
Date,	16,	18,	5.	13,	4, 9.	2.
Least daily	0	0	0	0	0.5	1
Date,	12 days.	15 days.	16 days	3.	2.	13.
Six Inches.						
Monthly mean	31.6	31.3	31.2	45.6	61.6	67.0
Extremes:						
Monthly maximum	34.5	33	32	60	68	73.5
Date,	1,	14,	1, 2, 30, 31.	18, 20.	17,	22.
Monthly minimum	29	27	26	32	52	59
Date,	6, 16.	17, 22.	5.	8 days	3.	2.
Mean maximum	31.8	31.5	31.3	46.8	63.0	68.6
Mean minimum	31.3	31.0	30.8	43.7	59.2	64.0
Range:						
Monthly	5.5	6.0	6.0	28	16	14.5
Mean daily	0.44	0.57	0.50	3.13	3.87	4.60
Greatest daily	2	3	5	9.5	8	8
Date,	16,	18, 22.	5.	13.	9.	2.
Least daily	0	0	0	0	0	0.5
Date,	15 days	18 days.	20 days.	2, 3, 4.	2.	13.
Twelve Inches.						
Monthly mean	33.5	33.2	32.5	44.3	58.7	66.0
Extremes:						
Monthly maximum	36.5	34	33	56	65.5	71
Date,	1.	13, 14	1, 3, 4, 29, 30, 31.	20.	17.	22.
Monthly minimum	32.5	32	32.5	32.5	52.5	61
Date	17.	23.	28 days.	3, 4, 5.	3.	2.

Mean maximum,		33.5		33.2		52.6		44.9		61.0		66.8
Mean minimum		33.5		33.1		32.5		43.6		53.1		65.1
Range:												
Monthly,		4.0		2.0		0.5		17.5		13		16
Mean daily,		0.01		0.03		0.06		1.28		1.42		1.77
Greatest daily,		0.5		0.5		0.5		4.5		3.5		3.5
Date,	1, 11, 17, 30,		12, 22,		3, 4, 29, 30,		13,		9,		26,	
Least daily,		0		0		0		0		0		0.5
Date,		27 days.		27 days.		27 days.		1, 2, 3, 4, 6, 7,		2, 18, 19,		7, 10, 25,
Twenty-four Inches.												
Monthly mean,		36.1		34.7		34.0		41.7		56.7		63.1
Extremes:												
Monthly maximum,		39		35		34		51		60		66
Date,	., 2,			18 days.		30 days.		30,		18, 19, 28, 29, 30, 31,		23,
Monthly minimum,		35		33.5		33.5		33.5		51		60
Date,		11 days.	29		30, 31,			1, 2, 3, 4, 5,		1, 2, 3, 4,		1, 2,
Mean minimum,		36.1		34.7		34		41.9		56.9		63.2
Mean maximum,		36.1		34.7		34		41.6		56.6		62.9
Range:												
Monthly,		4		1.5		0.5		17.5		9		6
Mean daily,		0.03		0.01		0.03		0.30		0.27		0.23
Greatest daily,		0.5		0.5		0.5		1		1		1.5
Date,	2, 21,		7,		30, 31,		13, 14, 18, 22,		8,		18,	
Least daily,		0		0		0		0		0		0
Date,		29 days.		28 days.		29 days.		15 days.		12 days.		19 days.

Summary of Soil Temperature for 1896—Continued.

	July		August		September.		October.		November.		December.	
Atmosphere.												
Monthly mean,		71.1		69.9		62.1		47.2		46.3		30.8
Monthly maximum,		89		93		91		72		71		60
Monthly minimum,		50		45		35		26		21		5
Mean daily range,		18.3		18.8		21.6		16.9		18.8		15
Greatest daily range,		30		26		35		36		39		27
Least daily range,		10		8		8		6		7		8
Surface.												
Monthly mean,		73.4		70.9		62.5		47.1		43.7		30.3
Extremes.												
Monthly maximum,		88		92		92		70		64		52
Date,	12, 29		15,		11,		29, 30,		1, 2,		13,	
Monthly minimum,		60		56		42		34		26		13
Date,	24,		19,		23,		24, 25, 26,		30,		28,	
Mean maximum,		80.4		79.7		71.6		54.9		49.9		34.3
Mean minimum,		70.1		67.2		57.1		42.5		38.8		27.0
Range:												
Monthly,		28		36		50		36		38		39
Mean daily,		11.32		12.77		14.63		12.39		11.13		7.39
Greatest daily,		19		26		26		24		24		18
Date,	14,		30,		25,		26,		7,		17,	
Least daily,		4		1		2		2		0		1
Date,	21,		12		5, 30,		12, 14,		4,		9,	
One Inch												
Monthly mean,		71.8		71.4		63.2		48.2		44.2		32.1
Extremes.												
Monthly maximum,		81.5		84		83		60.5		59		44.5
Date,	29,		11, 15,		11,		2, 29,		5,		13,	
Monthly minimum,		62		58		46		35.5		32		23
Date,	25,		20,		23,		26,		30,		28,	
Mean maximum,		75.6		75.9		68.3		51.7		47.0		33.3
Mean minimum,		67.7		66.7		58.1		44.4		40.9		30.7
Range:												
Monthly,		19.5		26		37		25		27		21.5
Mean daily,		7.94		9.20		10.25		7.45		6.23		2.63
Greatest daily,		11.5		16		16.5		13		12		10
Date,	1,		15, 30,		25,		26,		2,		13,	
Least daily,		3		2		1		1.5		1.5		0
Date,	7, 20,		13,		5, 29,		14,		9, 29, 30,		18, 30,	

Three Inches.

Monthly mean,
Extremes:
Monthly maximum,
Date,
Monthly minimum,
Date,
Mean maximum,
Mean minimum,

Range:

Monthly,
Mean daily,
Greatest daily,
Date,
Least daily,
Date,

Six Inches.

Monthly mean,
Extremes:
Monthly maximum,
Date,
Monthly minimum,
Date,
Mean maximum,
Mean minimum,

Range:

Monthly,
Mean daily,
Greatest daily,
Date,
Least daily,
Date,

Twelve Inches.

Monthly mean,
Extremes:
Monthly maximum,
Date,
Monthly minimum,
Date,
Mean maximum,
Mean minimum,

Range:

Monthly
Mean daily,
Greatest daily,
Date,
Least daily,
Date,

Twenty-four Inches.

Monthly mean,

71.9		72.2		64.6		61.4		45.7		33.8	
78		83		78.5		61.5		57.5		41.5	
63	11,	60	12,	56	2,	38.5	5	32	13,	29.5	
74.0	20,	73.9	24,	67.3	25, 26,	51.6	10	46.8	29	34.2	
67.6		67.4		59.9		46.3		42.7		33.2	
15		23		28.5		23.0		25.5		12	
6.45		7.43		7.32		5.23		4.00		0.90	
11		12.5		12		8.5		8.5		5.5	
	15,		8, 9, 10		3, 19, 20,		16		13,		
0.5		3		9		0.5		0.5		0	
	31,		5,		12,		20, 30,			3 days.	
71.3		72.1		64.9		50.6		44.8		34.3	
76		80		73.5		60.5		55.5		41	
	9, 11,		11,		2,		5		13		
65		63		54		41.5		37.5		32	
	20,		24		26		30,		28, 29		
72.6		73.7		66.3		51.6		46.7		35.2	
69.1		69.0		62.3		48.8		44.5		34.6	
11		17		19.5		19		18		9	
4.16		4.60		4.63		2.81		2.27		0.56	
7.5		7		8		5.5		6		4	
	15, 17, 20, 29,		10,		27		16,		13,		
0.5		0.5		0.5		0.5		0		0	
	13,		13, 29,		12,		12, 14		1 days		
69.9		71.6		65.1		52.2		47.3		37.4	
73.5		77		70.5		60.5		54.5		41	
	11, 12,		14,		2,		5,		1, 15,		
67		67		58		45.7		41.5		4.5	
	19,		24, 25,		25, 28,		15		29, 30, 31		
71.1		72.3		65.9		52.6		47.8		37.6	
69.6		70.8		64.2		51.6		46.6		37.2	
6.5		10		12.5		15		13		6.5	
1.48		1.50		1.52		1.00		1.20		0.34	
2.5		2.5		4		3		3.5		1.5	
	3, 5, 11,		12,		27,		11, 16		13,		
0		0.5		0		0		0		0	
	13, 21,		29,		1, 4,		10, 19, 21,		17 days.		
67.6		69.8		65.1		54.1		48.6		40.3	

Summary of Soil Temperature for 1896—Continued.

	July.	August.	September.	October.	November	December.
Extremes:						
Monthly maximum,	69.5	72.5	67.5	61.5	52.5	46
Date,	30,31	12,13	1,13,14,15,16,	1,	5,6,	1,
Monthly minimum,	64.5	67.5	61	48.5	45	37.5
Date,	1	21,30	26,	26,	24,	28,29,30,31,
Mean maximum,	67.6	69.9	65.2	54.2	48.7	40.4
Mean minimum,	67.5	69.6	64.9	53.9	48.2	40.2
Range:						
Monthly,	5	5	6.5	13	7.5	8.5
Mean daily,	0.10	0.33	0.28	0.23	0.45	0.15
Greatest daily,	1	1	1	0.5	1.5	0.5
Date,	3	18,27,	20,21,	14 days	13	9 days
Least daily,	0	0	0	0	0	0
Date	26 days.	12 days.	15 days.	17 days.	6 days	22 days

Summary of Soil Temperature for 1896—Mean Monthly Temperature.

	January.	February.	March.	April.	May.	June.	July.	August.	September	October	November	December.
Air,	26.7	28.3	28.7	52.0	64.7	65.6	71.1	69.9	62.1	47.2	46.3	30.8
Surface,	27.4	30.4	31.1	50.5	63.9	68.1	73.4	70.9	62.5	47.1	43.7	30.3
One inch,	29.2	30.4	30.7	47.7	62.8	67.3	71.8	71.4	62.2	48.2	44.2	32.1
Three inches,	30.9	30.9	31.1	47.0	62.6	67.7	71.9	72.2	64.6	49.6	45.7	33.8
Six inches,	31.6	31.3	31.2	45.6	61.6	67	71.3	72.1	64.9	50.6	45.8	34.9
Twelve inches,	33.5	33.2	32.5	44.3	58.7	66	69.9	71.6	65.1	52.2	47.3	37.4
Twenty-four inches,	36.1	34.7	34	41.7	56.7	63.1	67.6	69.8	65.1	54.1	48.6	40.3

Summary of Soil Temperature for 1896—Mean Daily Range.

Air,	12.00	15.50	17.10	19.40	18.50	20.20	18.30	18.80	21.60	16.90	18.80	15.00
Surface,	8.25	5.00	8.39	11.73	11.68	12.30	11.32	12.77	14.63	12.39	11.13	7.39
One inch,	2.76	1.66	3.06	6.30	7.48	8.07	7.94	9.20	10.25	7.45	6.23	2.63
Three inches,	0.95	0.93	1.05	4.50	5.48	6.83	6.45	7.43	7.33	5.23	4.00	0.90
Six inches,	0.44	0.57	0.50	3.13	3.87	4.60	4.16	4.69	4.03	2.81	2.27	0.56
Twelve inches,	0.01	0.03	0.06	1.28	1.42	1.77	1.48	1.50	1.52	1.06	1.20	0.34
Twenty-four inches,		0.01	0.05	0.30	0.27	0.23	0.10	0.13	0.28	0.23	0.45	0.15

SUNSHINE RECORDS.

The method adopted by the United States Weather Service of recording the per cent. of cloudiness does not afford an approximation to the real duration of sunshine. The desirability of determining more closely the actual time of sunshine received at the Station led to the adoption of a piece of apparatus described in a former report by which the sun's image, as it travels over a spherical reflector, is photographed by a camera containing a piece of ordinary blue-print paper. Any break in sunshine causes a corresponding break in the arc of the photograph. This gives a record of the duration of sunshine and not of the relative intensity.

These observations were begun before the sowing season in April and continued until the sun's path was so far south that the recorder was shaded by the office building for a short time each morning, although situated quite a distance to the northwest of it. The following table shows the daily duration of sunshine in hours and minutes:

Sunshine Records for 1896.

Dates.	April.		May.		June.		July.		August.		September.		October.	
	H.	M.	H.	M.	H.	M	H	M.	H.	M.	H.	M.	H.	M.
1,	0	0	0	0	9	8	9	52	0	56	7	32	0	44
2,	7	16	0	0	8	44	9	56	4	8	4	28	7	44
3,	6	28	6	4	5	52	7	56	7	8	4	16	7	40
4,	5	48	12	4	1	20	3	36	8	44	9	28	0	0
5,	10	12	7	44	7	8	3	8	8	40	0	0	2	32
6,	9	32	10	12	2	52	0	0	9	0	6	40	2	56
7,	4	40	5	48	1	16	2	20	1	20	4	36	1	0
8,	11	4	2	16	6	36	0	0	6	48	7	0	6	44
9,	7	24	9	16	6	28	4	48	5	44	9	20	7	8
10,	0	28	8	36	5	12	7	24	2	52	8	44	8	8
11,	0	0	6	16	11	0	10	4	8	12	8	36	4	40
12,	6	56	3	0	6	48	9	4	5	4	4	24	0	0
13,	7	12	6	52	0	0	5	48	0	0	1	20	0	0
14,	0	28	4	14	0	44	3	28	9	48	4	4	0	0
15,	8	48	8	36	2	20	1	24	8	40	0	0	7	44
16,	8	32	9	24	0	0	10	0	0	0	9	32	0	0
17,	8	36	9	36	5	20	8	28	9	48	3	52	0	0
18,	10	16	6	12	8	0	8	48	4	20	8	32	0	0
19,	4	0	0	52	8	12	7	4	8	28	0	0	3	44
20,	9	4	0	0	4	16	0	0	6	0	8	32	0	0
21,	4	16	0	0	1	8	2	16	0	0	5	48	2	56
22,	11	24	4	44	7	12	0	36	0	0	0	0	6	36
23,	11	0	5	24	3	28	8	24	0	0	9	8	0	0
24,	0	0	3	0	0	0	0	0	0	0	8	48	0	0
25,	0	16	0	0	0	0	9	28	7	52	8	48	7	4
26,	10	48	2	32	9	20	5	12	4	56	7	52	8	0
27,	0	0	4	12	3	44	5	56	10	4	6	0	7	8
28,	0	0	3	52	2	40	0	0	7	48	0	0	4	12
29,	1	8	8	16	8	52	7	24	7	44	0	0	6	4
30,	5	44	4	52	10	52	7	28	8	32	5	12	1	48
31,	.....	.....	10	20	.....	.....	8	44	0	0	.....	.....	8	16
Means	5	42	4	27	4	57	5	26	5	15	5	25	3	38

WEEKLY CROP REPORTS.

For several years past the Station has been making weekly crop reports during the growing seasons to the Pennsylvania State Weather Service. Such reports are made from different portions of the State with a view to establishing a permanent record by which comparisons may be made in succeeding years.

These reports cover the period from April 1 to October 1, and contain the daily maximum and minimum temperatures, the approximate daily percentage of sunshine and the daily rain fall. Besides the specific data are reported under the head of "General Remarks" the effect of the weather on crops with their condition and progress during the week; also the damaging effects of high winds, excessive rains, drought, frost, hail, etc.

The following table gives besides the general remarks, the mean weekly maximum and minimum temperature, the mean percentage of sunshine and the total weekly rain fall. The reports cover the week ending with the date of the report.

Summary of Weekly Crop Reports 1896.

Report for the Week Ending.	Mean of maximum temperatures.	Mean of minimum temperatures.	Per cent. of sunshine	Rainfall in inches.	Remarks
April 3,	49.6	31.1	33.6	0.45	Wheat in poor condition. The plants were weakened by the fall drought, and the ground was bare and subjected to successive thawing and freezing during January and February. Ground still frozen. No field work done except hauling manure.
April 10,	43.0	26.4	65.7	0.14	Frost about out of the ground, but no farm work done, since the ground is still very wet. Some clover seed has been sown.
April 17,	74.6	50.4	55.0	0.30	The extreme heat has made a wonderful change. Plowing for oats seeding began on the 13th and has continued every day since. At a depth of six inches the temperature of the soil has risen 25 degrees during the week.
April 24,	74.1	50.3	60.7	0.90	Oats seeding has been in progress all the week and is about finished. Some plowing for corn has been done. Frost of the 23d not damaging.
May 1	63.3	49.0	27.1	0 01	Weather too cold for anything except grass to grow. Some oats are up. Wheat is improving, but some fields look wretched. Peaches and cherries promise a good crop.
May 8	69.0	49.6	51.4	0.15	Corn planting began on the 4th and still continues. Weather favorable for field work. Grass and small grains doing well.
May 15,	82.3	61.7	67.1	0.04	Corn up. Ground becoming very dry and all crops suffering in consequence.
May 22,	74.4	55.3	40.0	0.32	The little rain was beneficial, but much more is needed. Oats and corn look fairly well, but wheat and grass look bad. Much sorrel in the latter.
May 29,	73.3	56.6	33.3	0.41	Clover in full bloom. Wheat and rye headed out. Corn and oats continue to do well. No amount of rain now can bring the grass crop up to the average. Potatoes not all planted.
June 5	72.6	50.6	61.9	0 94	Potatoes, corn and oats growing rapidly. Clover fairly good, but timothy promises almost nothing. Rains of the past week made the ground in good condition.
June 12	77.3	58.7	47.1	1.70	Some grass about ready to cut. Wheat beginning to turn. Oats, corn and potatoes continue to grow rapidly.
June 19	74.4	54.1	55.7	1.20	Some oats in blossom. Hay harvest under way. Everything growing rapidly.

16—22—96

Summary of Weekly Crop Reports 1896—Continued.

Report for the Week Ending	Mean of maximum temperatures.	Mean of minimum temperatures.	Per cent. of sunshine.	Rainfall in inches.	Remarks.
June 26	76.1	58.4	35.7	1.41	Oats in full bloom. Haying in progress. Wheat ripening rapidly. Corn and potatoes continue to do well.
July 3,	[illegible]	56.3	[illegible]	[illegible]	Haying about finished, with the lightest crop for 13 years. Wheat being cut on some farms. Everything doing well.
July 10,	77.3	61.0	22.9	1.66	Heavy rain of the 9th lodged some oats and corn. Some haying discontinued in order to cut wheat, which is now all cut.
July 17,	81.0	63.2	65.7	0.51	Hay and wheat harvest finished. Oats ripening rapidly. Army worms made their appearance about the 12th. Have done some damage to barley and corn.
July 24	77.9	61.3	36.4	1.55	Oats about all cut. Army worms have stopped working after doing some damage to corn, oats and barley. Corn in silk and doing well.
July 31,	82.3	62.9	65.7	1.84	Oats all cut, but the wet weather has interfered with hauling them under cover. Wheat threshing in progress.
August 7,	83.6	62.6	64.3	0.47	Oats housed and being threshed. Grain above the average and straw heavy. Clover promises a good second crop.
August 14,	85.3	68.1	57.1	0.61	Second crop of clover harvested the first of the week. Potatoes promise a large crop. Apples fair.
August 21,	74.1	55.6	57.1	0.02	More clover harvested. Some plowing done for wheat seeding.
August 28,	76.1	58.1	62.9	0.34	Corn doing well and promises a good yield. Ground being prepared for wheat seeding. Some wheat already sown and some farmers waiting for rain before seeding.
September 4,	74.1	51.1	68.6	0.12	Ground becoming very dry. Wheat about all seeded. Apples and grapes abundant.
September 11,	75.4	51.4	75.7	0.54	Corn cutting well under way. Heat intense. Drought continues.
September 18,	78.1	60.4	45.3	0.45	Corn cutting nearly finished. Wheat up and doing well. Rains beneficial to wheat and grass.
September 25,	65.6	42.1	61.4	1.06	Corn all cut. Late potatoes being dug with large yield. Frosts not damaging.

NOTES ON THE METEOROLOGY OF 1896.

Below is presented a summary of those data most important from an agricultural standpoint, grouped so as to show the summary for the year, the winter season and for the growing season. Also a summary of the temperature and range in temperature at different depths of the soil is given. To these are added the dates of the principal stages of crop development.

Annual Summary.

Mean barometer for the year, corrected and reduced,	30.050 inches.
Highest barometer for the year (December 28),	30.861 inches.
Lowest barometer for the year (February 6),	28.948 inches.
Mean annual temperature,	49.5 degrees.
Highest temperature (August 9),	93 degrees.
Lowest temperature (February 17),	6 degrees.
Annual range of temperature,	99 degrees.
Mean daily range,	17.7 degrees.
Greatest daily range (May 9),	39 degrees.
Least daily range (January 24, 25),	4 degrees.
Mean relative humidity,	81.8 per cent.
Annual rainfall,	35.28 inches.
Greatest monthly rainfall (July),	5.56 inches.
Greatest daily rainfall (September 30),	2.40 inches.
Days on which .01 inch or more fell,	132
Mean percentage of cloudiness,	60.0
Days on which cloudiness averaged 80 per cent. or more,	138
Wind, total movement,	25,340 miles.
Wind, maximum velocity per hour (February 6),	28 miles.
Wind, greatest daily movement (March 2),	435 miles.

Winter of 1895-6, October-March.

Mean temperature,	34.3 degrees.
Lowest temperature (February 17),	6 degrees.
Total rainfall (rain and melted snow),	13.34 inches.
Total snowfall,	33.55 inches.
Greatest monthly snowfall (March),	17.95 inches.
Greatest daily snowfall (February 9),	6.0 inches.
Days on which snow fell,	29
Days on which cloudiness averaged 80 per cent. or more,	73

Growing Season of 1896, April-September.

Mean temperature,	64.2 degrees.
Highest temperature (August 9),	93 degrees.
Lowest temperature (April 3),	21 degrees.
Mean daily range,	19.5 degrees.

Greatest daily range (May 19), ... 39 degrees.
Last frost in spring, ...April 23.
First frost in fall, ...September 24.
Mean relative humidity, ...77.3 per cent.
Total rainfall, ...20.0 inches.
Greatest daily rainfall (September 30), ...2.40 inches.
Days on which .01 inch or more fell, ...69
Mean percentage of cloudiness, ...55.5
Days on which cloudiness averaged 80 per cent. or more,.....62
Average hours of sunshine per day,.....4 hours, 59 minutes.

Soil Temperature—Daily Mean.

At surface, ...64.9 degrees.
At one inch depth, ...64.0 degrees.
At three inches depth, ...64.3 degrees.
At six inches depth, ...63.8 degrees.
At twelve inches depth, ...62.6 degrees.
At twenty-four inches depth, ...60.7 degrees.

Highest Recorded Temperature.

At surface (August 15; September 11), ... 92 degrees.
At one inch depth (August 11, 15),..... 84 degrees.
At three inches depth (August 11), ... 83 degrees.
At six inches depth (August 9, 11), ... 80 degrees.
At twelve inches depth (August 11, 12), ... 77 degrees.
At twenty-four inches depth (August 12,13).....72.5 degrees.

Lowest Recorded Temperature.

At surface (April 3), ... 27 degrees.
At one inch depth (April 4), ... 30 degrees.
At three inches depth (April 3, 4, 5, 6),..... 32 degrees.
At six inches depth (April, 8 days),..... 32 degrees.
At twelve inches depth (April 3, 4, 5),.....32.5 degrees.
At twenty-four inches depth (April 1, 2, 3, 4, 5).....33.5 degrees.

Mean Daily Range.

At surface, ...12.41 degrees.
At one inch depth, ... 8.21 degrees.
At three inches depth, ... 6.33 degrees.
At six inches depth, ... 4.06 degrees.
At twelve inches depth, ... 1.50 degrees.
At twenty-four inches depth, ... 0.30 degrees.

Greatest Daily Range.

At surface (August 30), ... 26 degrees.
At one inch depth (June 3), ... 19 degrees.

At three inches depth (August 15), ...12.5 degrees.
At six inches depth (April 13), ...9.5 degrees.
At twelve inches depth (April 13), ... 4.5 degrees.
At twenty-four inches depth (June 18), ... 1.5 degrees.

Principal Periods of Crop Development.

Wheat, seeded, ...September 1--6, 1895.
In bloom, ...June 1, 1896.
Ripening, ...June 12.
Cut, ...July 3.
Oats, seeded, ...April 15--24.
Ripening, ...July 17.
Cut, ...July 20--24.
Corn, planted, ... May 4.
In silk, ... July 24.
Cut, ...September 11.
Husking begun, ... September 25.
Potatoes, planted, ... May 15.
Late varieties harvested, ... September 25.
Grass in bloom, ... June 5.
Cut, ...June 26.
Clover, in bloom, ...May 29.
Cut, ...June 20.

The mean temperature for the year 1896 was slightly above the normal and the annual range in temperature was about normal. The total precipitation fell five and one-half inches below the average for the nine preceding years and was poorly distributed, April and May being so dry as to cause the lightest grass crop during thirteen years. A good second crop helped matters somewhat. The wheat crop also was light, probably owing to the drought of the previous fall, the insufficient snow covering in January and February, and the dry spring. The other crops recovered with the abundant rainfall of June and July and gave an excellent yield, although some oats and corn were injured by army worms.

The rains of September and October have made the young wheat look very promising and it begins the winter in a vigorous condition. The amount of sunshine was about the average and there were no damaging frosts.

Weather Signals.

By arrangement with the Pennsylvania State Weather Service and through the courtesy of the Pennsylvania Railroad, the Station is in daily receipt of the weather predictions for Pennsylvania, issued by the United States Weather Bureau. These predictions cover the weather (whether rainy or fair) temperature, and wind for the day

of issue. To secure a speedy and widespread dissemination of these predictions, the State Weather Service has issued signal flags by means of which the weather and temperature for thirty-six hours after 7 A. M., of the day for which the prediction has been made, may be indicated These flags the Station displays from the flagstaff on top of the college tower, whence they are visible for quite a distance on every side.

EXCHANGES.

The publications of this Station are sent regularly to the leading agricultural papers of the country, as well as to all newspapers in the State. The following agricultural papers have been sent to the Station regularly during a whole or part of the year, in exchange for its publications:

The Australian Farm and Home and Veterinary Record, Melbourne, Aus.
California Cultivator and Poultry Keeper, Los Angeles, California.
Farming, Toronto, Canada.
Connecticut Farmer, Hartford, Conn.
Mark Lane Express, London, England.
Sugar, London, England.
Veterinary Record, London, England.
La Laiterie, Paris, France.
Southern Cultivator, Atlanta, Georgia.
American Creameryman, Chicago, Ills.
American Sheep Breeder and Wool Grower, Chicago, Ills.
Breeders' Gazette, Chicago, Illinois.
Chicago Produce, Chicago, Illinois.
Farmers' Review, Chicago, Illinois.
Elgin Dairy Report, Elgin, Illinois.
Farmers' Magazine, Springfield, Illinois.
Farmers' Guide, Huntingdon, Indiana.
Agricultural Epitomist, Indianapolis.
Drainage Journal, Indianapolis, Indiana.
Indiana Farmer, Indianapolis, Indiana.
Jersey Bulletin, Indianapolis, Indiana.
Swine Breeders' Journal, Indianapolis, Indiana.
Creamery Gazette, Des Moines, Iowa.
Homestead, Des Moines, Iowa.
Wallaces' Farmer, Des Moines, Iowa.
Creamery Journal, Waterloo, Iowa.
Industrialist, Manhattan, Kansas.
Industrial American, Lexington, Kentucky.
Louisiana Planter, New Orleans, Louisiana.

The Southern Farmer, New Orleans, Louisiana.
Baltimore Sun, Baltimore, Maryland.
American Horse Breeder, Boston, Mass., and New York.
New England Farmer, Boston, Massachusetts.
Our Grange Home, Boston, Massachusetts.
Farm and Home, Springfield, Massachusetts.
Grange Visitor, Charlotte, Michigan.
Detroit Free Press, Detroit, Michigan.
Farm, Stock and Home, Minneapolis, Minnesota.
The Market Garden, Minneapolis, Minnesota.
Montana Fruit Grower, Missoula, Montana.
Hospodar, Omaha, Nebraska.
Mirror and Farmer, Manchester, New Hampshire.
Poultry Monthly, Albany, New York.
Practical Dairyman, Chatham, New York.
American Agriculturist, New York, N. Y.
American Dairyman, New York, N. Y.
New York Produce Review, New York, N. Y.
New York Farmer, Port Jervis, N. Y.
Rural New Yorker, New York, N. Y.
The Agricultural Student, Columbus, Ohio.
American Grange Bulletin, Cincinnati, Ohio.
Farmers' Home, Dayton, Ohio.
Farm and Fireside, Springfield, Ohio.
Farm, Field and Forum, Guthrie, Oklahoma.
Oregon Agriculturist, Portland, Oregon.
The Pennsylvania Farmer, Meadville, Pa.
Farmers' Friend, Mechanicsburg, Pa.
American Fertilizer, Philadelphia, Pa.
Farm Journal, Philadelphia, Pa.
Practical Farmer, Philadelphia, Pa.
Sugar Beet, Philadelphia, Pa.
National Stockman, Pittsburgh, Pa.
Holstein-Friesian Register, Brattleboro, Vt.
Progressive South, Richmond, Va.
Southern Planter, Richmond, Va.
Pacific Coast Dairyman, Tacoma, Washington.
West Virginia Farm Reporter, Charleston, W. Va.
Hoard's Dairyman, Fort Atkinson, Wis.

DISTRIBUTION OF SEEDS OF VARIETIES OF FARM CROPS.

Many inquiries having been received from persons living in various parts of the State who desire to test or purchase seeds of some of the varieties grown here, we take this means of stating that the Station does not make any free distribution of seeds. We give in our reports the source from which we obtain seeds, and farmers can obtain the same by addressing the parties named. We endeavor to grow each variety true to name and use seed from reliable persons or dealers. The small surplus of each variety remaining after securing our seed for the following season is kept, and we will supply parties desiring the same, as long as our supply lasts, charging a moderate price which hardly covers the expense of keeping seed pure and preparing it for shipment.

LIST OF STATION PUBLICATIONS.

Reports:

1887,* 1888,* 1889,* 1890,* 1891,* 1892, 1893, 1894,* 1895.*

Bulletins:

*October, 1887, Bulletin No. 1.—Soiling Crops.

*January, 1888, Bulletin No. 2.—Experiments with Phosphates.

*April, 1888, Bulletin No. 3.—Composition and Digestibility of Corn Stover.

*July, 1888, Bulletin No. 4.—Seed Germinations.

*October, 1888, Bulletin No. 5.—Digestibility of Soiling Rye.

*January, 1889, Bulletin No. 6.—Tests of Varieties, 1888.

*April, 1889, Bulletin No. 7.—Tests of Varieties, 1888.

*July, 1889, Bulletin No. 8.—Systematic Testing of New Varieties. Germination Tests.

October, 1889, Bulletin No. 9.—Digestibility of Corn Fodder and Silage.

*January, 1890, Bulletin No. 10.—Should Farmers Raise Their Own Vegetable Seeds? Notes on New Varieties of Vegetables. Tests of Agricultural Varieties, 1889.

April, 1890, Bulletin No. 11.—Indian Corn as a Grain and Forage Crop.

*July, 1890, Bulletin No. 12.—Simple Methods of Determining Milk Fat.

*October, 1890, Bulletin No. 13.—Black Knot on Plums. A Few Ornamental Plants.

*January, 1891, Bulletin No. 14.—Tests of Varieties of Vegetables for 1890.

*April, 1891, Bulletin No. 15.—Influence of Variety and Rate of Seeding on Yield of Ensilage Corn.

*July, 1891, Bulletin No. 16.—Culture of the Chestnut for Fruit. Analysis of Several Varieties of Chestnuts.

October, 1891, Bulletin No. 17.—The Value of Cotton Seed Meal as Compared With Bran for the Production of Butter.

January, 1892, Bulletin No. 18.—Notes on New and Old Varieties of Orchard Fruits and Small Fruits.

*April, 1892, Bulletin No. 19.—Information on Spraying Fruits.

July, 1892, Bulletin No. 20.—Tests of Dairy Apparatus.

*October, 1892, Bulletin No. 21.—The Koch Test for Tuberculosis.

*January, 1893, Bulletin No. 22.—Tests of Dairy Apparatus.

April, 1893, Bulletin No. 23.—Forest Fires. Experience with Evergreens in Pennsylvania.

*July, 1893, Bulletin No. 24.—Influence of Quantity of Food Upon Economy of Milk and Butter Production.

October, 1893, Bulletin No. 25.—Small Fruits in 1893.

*January, 1894, Bulletin No. 26.—Mangels and Sugar Beets vs. Silage. Yield, Cost and Feeding Value.

April, 1894, Bulletin No. 27.—Tests of Cream Separators.

July, 1894, Bulletin No. 28.—Cotton Seed Feed for Dairy Cows.

October, 1894, Bulletin No. 29.—Tuberculosis in Cattle.

*January, 1895, Bulletin No. 30.—Tobacco Experiments.

April, 1895, Bulletin No. 31.—Report of the Director for 1894.

*July, 1895, Bulletin No. 32.—Small Fruits in 1894.

October, 1895, Bulletin No. 33.—Directions for Using the Babcock Milk Test.

January, 1896, Bulletin No. 34.—A Phosphate Deposit in Juniata County.

April, 1896, Bulletin No. 35.—A Soil Test with Fertilizers.

May, 1896, Bulletin No. 36.—Chestnut Culture for Fruit.

November, 1896, Bulletin No. 37.—The Peach Industry in Pennsylvania.

*Reports and Bulletins marked thus (*) are out of print and cannot be supplied.

APPENDIX.

Detailed Meteorological Records

FOR 1896.

W. S. SWEETSER.

Meteorological Records for 1896—Barometric Pressure in Inches—Corrected and Reduced.

Dates	January			February			March.			April.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1,	30.051	30.091	30.071	29.911	29.743	29.827	29.506	29.706	29.606	30.020	29.832	29.926
2,	30.123	29.789	29.959	29.876	29.850	29.863	29.900	30.002	29.951	29.821	29.875	29.848
3,	29.767	30.087	29.927	29.772	29.710	29.741	30.176	30.204	30.190	29.852	29.983	29.918
4,	30.355	30.468	30.412	29.730	29.769	29.750	30.243	30.184	30.214	30.102	30.218	30.160
5,	30.393	30.465	30.429	29.844	29.796	29.820	30.239	30.116	30.178	30.337	30.227	30.282
6,	30.539	30.423	30.484	29.164	28.948	29.056	30.057	29.853	29.955	30.181	30.171	30.176
7,	30.191	30.067	30.129	29.546	29.840	29.693	29.542	29.617	29.580	30.168	30.369	30.269
8,	30.306	30.055	30.181	30.054	29.850	29.952	29.907	30.040	29.974	30.536	30.476	30.506
9,	29.892	29.949	29.921	29.467	29.609	29.538	30.078	29.973	30.026	30.446	30.197	30.322
10,	30.074	30.192	30.133	29.870	29.743	29.807	29.856	29.756	29.806	30.213	30.302	30.258
11,	30.262	30.153	30.208	29.856	30.000	29.928	29.616	29.275	29.496	30.287	30.211	30.249
12,	29.863	29.947	29.905	30.316	30.221	30.269	29.570	30.051	29.811	30.304	30.188	30.246
13,	30.170	30.103	30.137	29.894	29.567	29.731	30.276	30.467	30.372	30.097	29.833	29.965
14,	30.268	30.436	30.352	30.063	30.215	30.139	30.619	30.547	30.583	29.843	29.967	29.905
15,	30.579	30.504	30.542	30.062	29.820	29.941	30.362	30.043	30.203	30.139	30.049	30.094
16,	30.450	30.249	30.350	30.189	30.366	30.278	29.944	29.842	29.893	30.142	30.108	30.125
17,	30.268	30.173	30.221	30.612	30.435	30.524	30.094	30.221	30.158	30.079	29.955	30.017
18,	30.177	29.984	30.081	30.278	29.892	30.085	30.358	30.121	30.240	30.019	29.923	29.971
19,	29.982	30.122	30.052	29.439	29.662	29.552	29.488	29.284	29.386	30.014	30.025	30.020
20,	30.171	30.148	30.160	29.995	30.051	30.023	29.702	30.045	29.874	30.165	29.876	30.021
21,	30.154	30.192	30.173	30.334	30.441	30.388	30.277	30.110	30.194	29.813	29.705	29.759
22,	30.230	30.235	30.233	30.445	30.220	30.333	30.075	30.154	30.115	30.040	30.098	30.069
23,	30.231	30.056	30.129	30.107	29.912	30.010	30.464	30.482	30.473	30.256	29.981	30.119
24,	29.648	29.671	29.660	29.904	29.968	29.936	30.327	30.447	30.387	30.053	30.011	30.032
25,	29.945	30.094	30.020	30.165	30.070	30.118	30.332	29.947	30.140	30.118	30.078	30.098
26	30.156	30.196	30.176	29.693	29.723	29.708	29.654	29.839	29.747	30.133	30.085	30.109
27,	30.263	30.216	30.240	29.849	29.776	29.813	30.081	30.163	30.122	30.251	30.215	30.233
28,	30.320	30.275	30.298	29.825	29.778	29.802	30.239	29.989	30.114	30.253	30.169	30.211
29,	30.273	30.204	30.239	29.762	29.554	29.658	29.825	29.765	29.795	30.183	30.018	30.101
30,	30.234	30.314	30.274	.....	.....	.....	29.789	29.973	29.881	30.091	30.046	30.069
31	30.367	30.205	30.286	.....	.....	.....	30.199	30.105	30.152	.....	.....	.....
Means	30.184	30.163	30.174	29.932	29.879	29.906	30.026	30.010	30.018	30.132	30.073	30.103

Barometric Pressure—Continued.

Dates.	May.			June.			July.			August.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1,	30.082	30.020	30.051	30.018	30.070	30.044	30.230	30.138	30.184	30.148	29.872	30.010
2,	30.071	30.024	30.048	30.172	30.127	30.150	30.175	30.066	30.121	29.773	29.865	29.819
3,	30.000	29.925	29.963	30.234	30.056	30.145	30.103	29.993	30.048	30.022	29.945	29.984
4,	30.010	29.870	29.940	30.059	30.016	30.038	29.968	29.773	29.871	30.031	29.971	30.001
5,	29.896	29.916	29.906	30.111	30.006	30.059	29.822	29.865	29.844	30.018	29.937	29.978
6,	30.114	30.139	30.127	30.050	30.004	30.027	29.906	29.861	29.884	30.038	29.982	30.010
7,	30.318	30.239	30.279	30.017	29.879	29.948	29.905	30.012	29.959	30.019	29.966	29.993
8,	30.313	30.135	30.224	29.762	29.565	29.664	30.102	30.058	30.080	30.022	29.932	29.977
9,	30.119	29.966	30.043	29.601	29.557	29.579	29.983	30.045	30.014	29.970	29.948	29.959
10,	29.972	29.849	29.911	29.629	29.748	29.689	30.217	30.116	30.167	30.014	29.973	29.994
11,	29.879	29.838	29.859	29.820	29.715	29.718	30.176	30.108	30.142	30.024	30.002	30.013
12,	29.929	29.933	29.931	29.704	29.595	29.650	30.107	29.971	30.039	.....	30.035	.....
13,	30.065	29.973	30.019	29.701	29.847	29.774	29.984	29.879	29.932	30.074	30.048	30.061
14,	29.965	29.808	29.887	29.910	30.059	29.985	29.915	29.832	29.874	30.075	30.029	30.052
15,	30.011	30.090	30.051	30.197	30.131	30.164	29.757	29.692	29.725	30.138	30.018	30.073
16,	30.306	29.988	30.147	30.161	30.055	30.108	29.794	29.895	29.845	29.982	29.917	29.950
17,	29.853	29.886	29.870	30.063	29.920	29.994	30.109	30.188	30.149	30.081	30.044	30.063
18,	29.887	29.870	29.879	30.016	29.949	29.983	30.336	30.248	30.292	30.043	30.043	30.043
19,	29.819	29.980	29.900	30.024	29.922	29.973	30.274	30.156	30.215	30.200	30.248	30.224
20,	30.166	30.199	30.183	29.998	29.955	29.977	29.945	30.072	30.009	30.305	30.099	30.202
21,	30.134	30.058	30.096	29.947	29.834	29.891	30.020	29.996	30.008	30.002	29.929	29.966
22,	30.022	30.016	30.020	29.882	29.887	29.884	29.958	29.804	29.881	29.925	29.875	29.900
23,	30.155	30.137	30.146	30.084	30.077	30.081	29.972	30.021	29.997	29.892	29.956	29.924
24,	30.213	30.153	30.183	30.084	30.140	30.112	29.917	29.688	29.803	30.031	29.989	30.010
25,	30.146	29.947	30.047	30.256	30.178	30.217	29.982	30.041	30.012	30.055	30.014	30.035
26,	29.768	29.788	29.778	30.070	30.068	30.069	30.102	29.960	30.031	30.046	29.949	29.998
27,	29.934	29.924	29.929	30.105	29.892	29.999	29.929	29.874	29.902	29.811	29.805	29.808
28,	29.743	29.691	29.717	29.744	29.683	29.661	30.014	29.983	29.999	30.335	30.305	30.320
29,	29.876	29.871	29.874	29.839	30.016	29.928	30.043	29.844	29.944	30.341	30.123	30.232
30,	29.914	29.736	29.825	30.221	30.181	30.201	29.881	29.865	29.873	30.074	29.800	29.937
31,	29.745	29.845	29.795	.....	.....	.....	30.019	30.085	30.052	29.846	29.942	29.894
Means,	30.013	29.961	29.988	29.983	29.928	29.957	30.021	29.972	29.997	30.044	29.896	30.014

Barometric Pressure—Continued.

Dates.	September.			October.			November.			December.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1,	30.224	30.229	30.232	29.882	30.023	29.953	30.004	29.958	29.981	30.464	30.478	30.471
2,	30.294	30.034	30.164	30.051	30.007	30.029	30.187	30.167	30.177	30.506	30.355	30.431
3,	29.927	29.975	29.951	30.121	30.134	30.128	30.260	30.194	30.227	30.384	30.388	30.386
4,	30.193	30.085	30.139	30.193	30.185	30.189	30.143	29.908	30.026	30.281	30.047	30.164
5,	30.039	29.800	29.920	30.186	30.152	30.169	29.514	29.690	29.602	30.091	30.020	30.055
6,	29.776	29.921	29.849	30.167	29.922	30.045	29.947	29.917	29.932	30.053	30.077	30.065
7,	30.035	30.072	30.054	30.040	30.130	30.085	30.009	29.854	29.932	30.101	30.104	30.103
8,	30.213	30.117	30.165	30.263	30.337	30.300	29.941	29.957	29.949	30.240	29.800	30.020
9,	30.148	29.944	30.046	30.477	30.450	30.464	30.065	30.183	30.124	29.765	29.675	29.720
10,	30.011	29.866	29.939	30.467	30.383	30.425	30.327	30.145	30.236	29.818	29.728	29.773
11,	29.978	30.020	29.999	30.336	30.166	30.251	29.959	30.049	30.004	30.023	30.128	30.076
12,	30.148	30.173	30.163	30.135	30.087	30.011	30.120	30.084	30.102	30.031	29.850	29.941
13,	30.228	30.174	30.201	29.949	29.803	29.872	30.008	30.092	30.050	29.704	29.698	29.701
14	30.148	29.903	30.026	29.805	29.848	29.827	30.294	30.224	30.059	30.091	30.111	30.101
15,	29.942	29.929	29.936	29.856	29.738	29.797	30.117	29.913	30.115	30.073	29.918	29.996
16,	29.986	29.811	29.899	29.688	29.800	29.744	30.188	30.160	30.174	29.952	30.139	30.046
17,	29.726	29.738	29.732	30.084	29.984	30.034	30.160	30.158	30.159	30.313	30.166	30.240
18,	29.913	29.884	29.899	29.898	30.051	29.975	30.154	29.982	30.068	29.973	29.915	29.944
19,	29.754	29.918	29.836	30.170	30.061	30.116	30.122	30.338	30.230	30.196	30.170	30.183
20,	30.191	30.105	30.148	29.961	29.928	29.945	30.533	30.472	30.503	30.125	30.018	30.072
21,	30.052	29.847	29.950	29.856	30.050	29.953	30.317	29.997	30.157	29.940	29.948	29.944
22,	29.819	29.994	29.907	30.168	30.025	30.097	30.348	30.607	30.478	29.978	29.690	29.834
23,	30.296	30.235	30.266	29.908	29.637	29.773	30.649	30.486	30.568	29.906	30.228	30.067
24,	30.293	30.242	30.268	29.735	29.969	29.852	30.368	30.460	30.414	30.501	30.555	30.528
25,	30.276	30.153	30.215	30.158	30.163	30.161	30.461	30.393	30.427	30.651	30.464	30.558
26,	30.264	30.159	30.212	30.179	30.122	30.150	30.284	30.049	30.167	30.262	30.447	30.355
27,	30.123	30.031	30.077	30.262	30.222	30.242	29.978	29.947	29.963	30.703	30.817	30.760
28,	30.157	30.130	30.144	30.301	30.219	30.260	30.113	30.242	30.178	30.861	30.642	30.752
29,	30.025	29.573	29.799	30.255	30.112	30.184	30.423	30.411	30.417	30.551	30.422	30.487
30,	29.720	29.660	29.690	29.957	29.777	29.867	30.487	30.455	30.471	30.394	30.305	30.350
31,	.....	.....	.....	29.918	29.866	29.892	.....	.....	.....	30.380	30.450	30.415
Means	30.063	29.993	30.028	30.078	30.040	30.059	30.183	30.153	30.168	30.204	30.153	30.179

Meteorological Record for 1896—Temperature in Degrees Fahrenheit.

Dates.	January.						February.						March.					
	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.
1,	19	21	29	19	24	10	35	46	50	34	42	16	32	31	36	30	33	6
2,	19	39	43	15	29	18	34	32	46	31	38.5	15	25	23	31	23	27	8
3,	30	14	43	14	28.5	29	28	28	33	27	30	6	14	20	31	13	22	18
4,	3	2	14	2	8	12	28	29	32	27	29.5	5	14	21	30	12	21	18
5,	1	5	10	1	5.5	9	31	33	39	33	36	6	13	33	42	10	26	32
6,	2	11	14	2	8	12	36	36	41	30	35.5	11	25	47	47	22	34.5	25
7,	16	21	21	11	16	10	32	30	36	30	33	6	38	31	40	31	35.5	9
8,	12	23	26	12	19	14	30	31	34	28	31	6	28	26	32	25	28.5	7
9,	22	30	31	20	25.5	11	27	25	31	25	28	6	25	29	34	23	28.5	11
10,	25	23	31	22	26.5	9	25	31	35	24	29.5	11	26	29	31	24	27.5	7
11,	21	24	28	21	24.5	7	22	24	40	23	31.5	17	28	24	30	24	27	6
12,	28	34	42	23	32.5	19	15	26	32	14	23	18	14	13	22	12	17	10
13,	18	26	34	17	25.5	17	30	40	40	24	32	16	8	12	21	4	12.5	17
14,	20	23	26	20	23	6	25	26	41	25	33	16	11	20	27	7	17	20
15,	21	21	27	21	24	6	35	45	50	25	37.5	25	18	22	22	13	17.5	9
16,	12	30	36	11	23.5	25	19	9	45	9	27	36	22	28	28	20	24	8
17,	20	28	36	18	27	18	—6	8	11	—6	2.5	17	21	28	36	19	27.5	17
18,	22	26	41	21	31	20	0	20	22	—3	9.5	25	18	36	41	14	27.5	27
19,	32	33	38	31	34.5	7	20	10	25	4	14.5	21	33	37	42	23	33	20
20,	30	30	34	29	31.5	5	0	5	10	—2	4	12	23	20	37	19	28	18
21,	31	31	35	29	32	6	6	10	14	4	9	10	21	32	40	14	27	26
22,	30	32	34	27	30.5	7	12	27	33	8	20.5	25	41	38	47	28	37.5	19
23,	30	35	36	29	32.5	7	38	40	46	26	36	20	16	16	30	15	22.5	15
24,	38	36	38	34	36	4	39	33	42	33	37.5	9	10	21	36	8	19.5	33
25,	34	36	38	34	36	4	14	21	33	14	23.5	19	23	39	40	19	29.5	21
26,	34	29	36	29	32.5	7	26	33	37	18	27.5	19	40	25	45	25	35	20
27,	22	26	30	21	25.5	9	28	40	49	24	36.5	25	18	28	33	17	25	16
28,	22	26	38	21	29.5	17	33	42	52	31	41.5	21	27	44	45	19	32	26
29,	25	39	39	21	30	18	40	38	44	35	39.5	9	40	53	56	38	47	18
30,	36	39	46	35	40.5	11	.....	.....	.....	.....	.....	.....	45	55	61	44	52.5	17
31,	31	35	39	30	34.5	9	.....	.....	.....	.....	.....	.....	41	49	60	34	47	26
Means.	22.8	26.7	32.7	20.6	26.7	12.0	24.2	28.1	36.0	20.5	28.3	15.5	24.6	29.8	37.2	20.1	28.7	17.1

Temperature—Continued.

Dates.	April.						May.						June.					
	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.
1,	42	42	50	38	44	12	51	53	60	50	55	10	55	57	67	46	56.5	21
2,	36	25	43	24	33.5	19	50	52	53	48	50.5	5	55	62	73	42	57.5	31
3,	22	23	32	21	26.5	11	55	63	69	51	60	18	59	68	75	45	60	30
4,	25	29	30	22	26	8	60	71	78	48	63	30	61	65	74	59	66.5	15
5,	28	39	47	24	35.5	23	63	63	77	53	65	24	64	70	81	57	69	24
6,	37	32	51	32	41.5	19	59	60	71	48	59.5	23	66	69	76	60	68	16
7,	28	29	34	26	30	8	54	59	67	52	59.5	15	67	68	74	61	67.5	13
8,	33	38	46	24	35	22	55	62	68	47	57.5	21	69	73	83	62	72.5	21
9,	38	35	50	27	38.5	23	71	79	90	51	70.5	39	69	67	79	64	71.5	15
10,	34	40	43	33	38	10	76	80	87	66	76.5	21	61	63	74	59	66.5	15
11,	39	43	46	37	41.5	9	76	77	87	68	77.5	19	60	65	75	49	62	26
12,	43	60	67	40	53.5	27	68	65	79	63	71	16	65	70	80	56	68	24
13,	54	71	83	49	66	34	61	71	79	59	69	20	61	57	70	54	62	16
14,	69	53	73	60	66.5	13	64	72	78	60	69	18	57	57	66	54	60	12
15,	55	70	80	49	64.5	31	66	65	76	65	70.5	11	56	64	72	52	62	20
16,	63	72	85	56	70.5	29	63	72	81	49	65	32	62	59	73	58	65.5	15
17,	75	78	88	62	75	26	74	72	86	60	73	26	58	65	77	53	65	24
18,	72	80	87	59	73	28	73	66	79	63	71	16	61	73	80	52	66	28
19,	68	76	86	62	74	24	71	61	72	60	66	12	68	74	83	56	69.5	27
20,	62	69	80	55	67.5	25	55	51	61	50	55.5	11	73	73	86	63	74.5	23
21,	63	64	73	57	65	16	51	58	61	48	54.5	13	73	67	84	63	73.5	21
22,	44	52	64	39	51.5	25	66	70	81	57	69	24	71	70	83	64	73.5	19
23,	47	59	63	35	49	28	62	65	74	58	66	16	59	62	71	53	62	18
24,	47	47	66	45	55.5	21	62	63	72	52	62	20	59	56	62	54	58	8
25,	46	52	54	44	49	10	59	62	63	56	59.5	7	56	61	64	53	58.5	11
26,	55	60	69	48	58.5	21	68	71	79	62	70.5	17	71	71	83	59	71	24
27,	53	54	61	51	56	10	68	69	79	58	68.5	21	65	66	73	55	64	18
28,	50	56	63	49	56	14	66	65	79	57	68	22	62	68	79	59	69	20
29,	51	63	71	48	59.5	23	55	59	67	53	60	14	67	66	76	55	65.5	21
30,	59	59	65	53	59	12	55	62	69	50	59.5	19	62	69	79	48	63.5	31
31							60	63	69	55	62	14						
Means	47.9	52.3	61.7	42.3	52.0	19.4	62.5	65.2	73.9	55.4	64.7	18.5	63.1	65.8	75.7	55.5	65.6	20.2

Temperature—Continued.

Dates	July.						August.						September.					
	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.
1	68	74	84	54	69	30	65	67	71	55	63	16	56	57	68	44	56	24
2	72	75	86	60	73	26	70	71	79	64	71.5	15	53	69	76	43	59.5	33
2	75	77	86	63	74.5	23	66	76	84	59	71.5	25	67	62	82	60	71	22
4	69	70	81	65	73	16	72	77	85	60	72.5	25	54	57	70	45	57.5	25
5	72	72	81	69	75	12	77	83	89	63	76	26	57	60	60	50	55	10
6	69	73	78	64	71	14	81	80	91	69	80	22	57	56	69	55	62	14
7	68	63	73	63	68	10	79	74	86	68	77	18	56	59	69	48	58.5	21
8	62	62	69	54	61.5	15			86	69	77.5	17	48	59	73	44	58.5	29
9	70	73	79	58	68.5	21	78	76	93	73	83	20	55	65	78	44	61	34
10	70	74	80	54	67	26	76	80	85	68	76.5	17	66	78	88	53	70.5	35
11	74	74	85	64	74.5	21	76	77	88	68	78	20	74	81	91	66	78.5	25
12	73	76	85	65	75	20	.....	71	90	71	80.5	19	70	68	90	65	77.5	25
13	74	75	86	65	75.5	21	69	66	74	66	70	8	65	66	75	64	69.5	11
14	69	73	81	65	73	16	68	72	81	62	71.5	19	67	73	81	63	72	18
15	74	75	82	70	76	12	66	75	85	59	72	26	66	66	75	65	70	10
16	65	63	75	62	68.5	13	72	74	81	69	75	12	56	62	73	50	61.5	23
17	60	63	73	52	62.5	21	61	62	74	56	65	18	62	67	77	58	67.5	19
18	61	69	77	50	63.5	27	60	58	69	51	60	18	62	69	76	58	67	18
19	68	73	79	61	70	18	56	58	68	49	58.5	19	65	52	73	50	61.5	23
20	72	70	79	68	73.5	11	53	64	71	48	59.5	23	46	53	63	43	53	20
21	74	75	81	69	75	12	63	63	71	57	64	14	44	60	67	40	53.5	27
22	74	73	84	67	75.5	17	68	68	74	54	64	20	55	48	61	48	54.5	13
23	64	66	75	60	67.5	15	72	69	80	67	73.5	13	39	48	55	35	45	20
24	57	70	70	54	62	16	65	68	78	63	70.5	15	50	55	67	40	53.5	27
25	64	69	77	58	67.5	19	60	69	78	55	66.5	23	46	65	73	39	56	34
26	66	72	79	55	67	24	68	74	80	65	72.5	15	58	68	77	53	64	22
27	73	69	89	66	67.5	23	62	64	73	58	65.5	15	60	68	77	55	66	22
28	71	76	84	65	74.5	19	57	60	79	45	57.5	25	55	60	70	53	61.5	17
29	76	79	86	67	76.5	19	56	65	74	57	65.5	17	62	65	66	58	62	8
30	75	68	85	64	74.5	21	59	69	78	54	66	24	51	51	68	50	59	18
31	68	66	76	65	75.5	21	59	61	71	55	63	16	.....	.....	.....	.....	.....	.....
Means	69.3	71.7	80.2	61.9	71.1	18.3	67	70.0	79.3	60.5	69.9	18.8	57.4	62.2	72 9	51.3	62.1	21.6

Temperature— Continued.

Dates.	October.						November.						December.					
	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.	8 a. m.	8 p. m.	Maximum.	Minimum.	Mean.	Range.
1,	52	56	62	47	54.5	15	52	55	63	49	56	14	18	21	33	17	25	16
2,	50	50	63	49	56	14	52	57	70	41	55.5	29	15	18	26	14	20	12
3,	41	50	57	37	47	20	45	56	66	41	53.5	25	12	20	28	11	19.5	17
4,	48	50	55	46	50.5	9	55	57	58	51	54.5	7	22	29	30	13	21.5	17
5,	47	46	55	43	49	12	60	46	66	45	55.5	21	35	42	43	26	34.5	17
6,	38	51	60	35	47.5	25	38	44	56	37	46.5	19	42	44	54	37	45.5	17
7,	45	42	53	41	47	12	37	51	62	34	48	28	43	42	49	34	41.5	15
8,	40	40	51	38	44.5	13	36	32	51	32	41.5	19	30	39	42	29	35.5	13
9,	33	40	53	28	40.5	25	31	30	40	27	33.5	13	37	42	47	36	41.5	11
10,	33	44	53	28	40.5	25	24	42	42	22	32	20	40	47	50	40	45	10
11,	40	46	55	36	45.5	19	42	48	54	35	44.5	19	38	37	47	36	41.5	11
12,	41	41	47	40	43.5	7	44	39	49	39	44	10	33	46	51	30	40.5	21
13,	43	43	46	40	43	6	32	29	39	29	34	10	44	50	60	33	46.5	27
14,	46	48	50	42	46	8	29	32	36	28	32	8	30	31	51	32	41.5	19
15,	46	53	64	46	55	18	41	50	58	28	43	30	31	32	51	28	39.5	23
16,	51	48	58	48	53	10	52	58	68	47	57.5	21	35	26	39	26	32.5	13
17,	41	45	52	39	45.5	13	62	58	65	54	59.5	11	20	31	37	19	28	18
18,	41	36	46	35	40.5	11	51	61	71	51	61	20	34	36	36	28	32	8
19,	32	34	45	27	36	18	49	34	62	34	48	28	26	26	36	25	30.5	11
20,	41	47	52	32	42	20	26	31	51	25	38	26	19	24	30	17	23.5	13
21,	49	36	53	36	44.5	17	34	43	43	30	36.5	13	26	34	32	22	27	10
22,	36	42	51	30	40.5	21	37	32	47	31	39	16	23	25	26	21	23.5	5
23,	34	43	50	31	40.5	19	30	39	39	26	32.5	13	23	12	29	12	20.5	17
24,	38	36	44	36	40	8	41	50	58	38	48	20	8	17	23	7	15	16
25,	34	39	50	27	38.5	23	44	58	64	42	53	22	18	14	22	13	17.5	9
26,	34	52	62	26	44	36	46	62	67	44	55.5	23	27	29	29	13	21	16
27,	40	51	66	36	51	30	62	66	68	60	64	8	19	14	29	14	21.5	15
28,	40	59	65	38	51.5	27	45	37	65	37	51	28	5	24	30	5	17.5	25
29,	54	63	72	51	61.5	21	28	28	52	28	50	24	18	36	39	15	27	24
30,	61	62	66	59	62.5	7	21	21	41	21	31	20	37	40	42	33	37.5	9
31,	56	56	67	52	59.5	15	.....	.....	.....	.....	.....	.....	41	37	45	36	40.5	9
Means.	42.7	46.7	55.6	38.7	47.2	16.9	41.6	44.9	55.7	36.9	46.3	18.8	27.4	31.1	38.3	23.3	30.8	15.0

Meteorological Reports for 1896—Dew Points (in Degrees Fahrenheit).

Dates.	January.			February.			March.			April.			May.			June.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.
1,	*18	18	18	35	40	37.5	32	25	28.5	40	42	41	47	49	48	43	46	44.5
2,	15	26	20.5	26	29	27.5	22	20	21	31	22	26.5	48	50	49	48	50	49
3,	27	14	20.5	28	28	28	10	16	13	19	21	20	53	58	55.5	48	57	52.5
4,	2	3	2	25	29	27	12	18	15	18	26	22	49	51	50	59	62	60.5
5,	1	5	3	28	31	29.5	13	21	17	26	26	26	53	42	47.5	61	62	61.5
6,	2	11	6.5	36	28	32	25	29	27	32	20	26	48	49	48.5	63	64	63.5
7,	12	19	15.5	27	27	27	33	28	30.5	8	26	22	49	50	49.5	64	65	64.5
8,	12	20	16	28	28	28	25	23	24	30	28	29	50	57	53.5	66	67	66.5
9,	20	27	23.5	24	22	23	18	26	22	28	32	30	61	57	59	64	61	62.5
10,	22	20	21	25	26	25.5	24	26	25	34	35	34.5	59	54	56.5	58	44	51
11,	20	21	20.5	15	21	18	25	24	24.5	37	41	39	59	60	59.5	45	49	47
12,	25	23	24	11	20	15.5	14	9	11.5	43	53	48	62	62	62	53	57	55
13,	16	20	18	30	38	34	8	11	9.5	50	67	58.5	52	58	55	54	55	54.5
14,	19	16	17.5	22	23	22.5	11	16	13.5	50	53	51.5	57	63	60	57	57	57
15,	19	18	18.5	30	27	28.5	17	22	19.5	50	57	53.5	54	47	50.5	54	59	56.5
16,	12	24	18	18	9	13.5	22	28	25	56	59	57.5	49	54	51.5	59	59	59
17,	18	25	21.5	—6	6	0	21	25	23	63	63	63	58	50	54	56	62	59
18,	20	28	24	0	12	6	17	25	21	61	58	59.5	49	60	54.5	59	62	60.5
19,	32	31	31.5	19	10	14.5	33	29	31	57	55	56	62	56	59	62	67	64.5
20,	30	27	28.5	0	5	2.5	20	16	18	50	58	54	46	49	47.5	67	69	68
21,	28	28	28	5	10	7.5	21	32	26.5	56	50	53	49	56	52.5	67	66	66.5
22,	27	30	28.5	10	24	17	36	26	36	32	40	36	61	55	58	65	53	59
23,	30	32	31	28	35	31.5	14	16	15	41	44	42.5	52	55	53.5	48	53	50.5
24,	36	36	36	32	30	31	10	18	14	45	47	46	52	55	53.5	57	54	55.5
25,	34	31	32.5	14	18	16	20	26	23	44	48	46	57	59	58	53	59	56
26,	34	26	30	26	28	27	30	22	26	46	47	46.5	62	53	57.5	67	56	61.5
27,	21	20	20.5	24	33	28.5	30	23	26.5	47	46	46.5	57	56	56.5	55	58	56.5
28,	20	20	20	30	40	35	21	32	26.5	48	53	50.5	61	51	56	60	60	60
29,	22	37	29.5	40	34	37	40	49	44.5	51	58	54.5	46	48	47	59	48	53.5
30,	34	35	34.5	.....	.....	.....	45	39	42	48	44	46	50	53	51.5	52	58	55
31,	28	32	30	.....	.....	.....	34	36	35	.....	.....	.....	55	58	57.5	.....	.....	.....
Means,	21.1	23.2	22.2	21.7	24.5	23.1	22.7	24.7	23.7	41.7	44.0	42.8	53.8	54.0	53.9	57.4	58.0	57.7

Dew Points—Continued.

Dates.	July.			August.			September.			October.			November.			December.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean	8 a. m.	8. p. m.	Mean.
1,	55	65	60	51	61	56	42	48	45	48	49	48.5	40	43	41.5	14	18	16
2,	66	64	65	67	63	65	47	58	52.5	44	44	44	42	44	43	15	14	14.5
3,	66	70	68	63	67	65	59	60	59.5	41	46	42.5	41	47	44	12	20	16
4,	68	69	68.5	68	68	68	52	54	53	44	48	46	48	55	51.5	19	29	24
5,	69	66	67.5	70	72	71	50	58	54	45	44	44.5	58	35	46.5	32	29	30.5
6,	66	69	67.5	73	70	71.5	54	48	51	38	51	44.5	28	40	34	29	37	33
7,	65	53	59	72	71	71.5	51	52	51.5	36	44	34.5	35	43	39	34	38	36
8,	55	59	57	72	72	72	46	50	48	35	33	34	25	23	24	30	39	34.5
9,	66	64	65	74	67	70.5	52	57	54.5	30	35	32.5	25	27	26	32	29	30.5
10,	59	67	63	69	73	71	61	68	64.5	30	40	35	24	32	27.5	33	36	34.5
11,	63	63	63	67	68	67.5	68	66	67	35	40	37.5	40	44	42	33	29	31
12,	64	67	65.5	.....	70	.....	67	68	67.5	41	41	41	40	34	37	30	35	32.5
13,	68	68	68	68	64	66	63	64	63.5	43	41	42	32	26	29	32	40	36
14,	66	72	69	62	64	63	66	69	67.5	44	42	43	26	32	29	27	25	26
15,	70	69	69.5	63	66	64.5	64	61	62.5	40	47	43.5	31	37	34	19	20	19.5
16,	57	56	56.5	68	65	66.5	51	55	53	45	40	42.5	42	47	42.5	32	23	27.5
17,	53	58	55.5	46	50	48	60	62	61	39	41	40	50	53	51.5	16	28	22
18,	56	59	57.5	53	51	52	57	63	60	41	41	36	50	52	51	26	31	28.5
19,	60	64	62	47	51	49	65	40	52.5	27	29	28	41	26	33.5	20	20	20
20,	68	69	68.5	49	54	51.5	37	43	40	39	47	43	20	28	24	19	21	20
21,	70	71	70.5	56	60	58	43	51	47	45	28	36.5	31	43	37	26	31	28.5
22,	70	69	69.5	60	67	63.5	52	42	47	31	35	33	32	27	29.5	20	22	21
23,	54	56	55	69	68	68.5	32	37	34.5	31	43	37	24	34	29	20	12	16
24,	55	67	61	60	60	60	40	46	43	33	28	30.5	39	46	42.5	8	13	10.5
25,	54	59	56.5	55	61	58	44	49	46.5	29	32	30.5	44	53	48.5	14	10	12
26,	60	68	64	62	65	63.5	51	51	51	29	37	33	46	55	50.5	24	26	25
27,	69	68	68.5	45	50	47.5	53	60	56.5	35	45	40	57	58	57.5	19	12	15.5
28,	68	70	69	50	49	49.5	53	55	54	38	54	46	45	35	40	5	21	13
29,	70	73	71.5	51	57	54	59	62	60.5	50	56	53	22	22	22	18	31	24.5
30,	68	67	67.5	54	56	55	41	49	45	56	59	57.5	18	18	18	37	40	38.5
31,	60	58	59	57	48	52.5	.....	.....	.....	47	37	42	.....	.....	.....	39	35	37
Means,	63.2	65.1	64.2	60.7	62.2	61.0	52.7	54.9	53.8	39.0	41.1	40.1	36.5	38.7	37.6	23.7	26.3	25.0

Meteorological Records for 1896—Percentage of Atmospheric Humidity.

Dates.	January.			February.			March.			April.			May.			June.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	3. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.
1,	93	86	89.5	100	79	89.5	100	79	89.5	92	100	96	87	87	87	65	66	65.5
2,	85	58	71.5	72	90	81	88	87	87.5	82	88	85	93	94	93.5	76	64	70
3,	89	100	94.5	100	100	100	83	86	84.5	86	93	89.5	94	84	89	67	67	67
4,	95	100	97.5	89	100	94.5	90	86	88	76	89	82.5	68	48	58	94	90	92
5,	100	100	100	90	95	92.5	100	62	81	95	58	76.5	69	46	57.5	90	77	83.5
6,	100	100	100	100	73	86.5	100	61	80.5	82	61	71.5	67	68	67.5	90	86	88
7,	84	93	88.5	80	89	84.5	83	90	86.5	68	89	78.5	82	72	77	93	90	91.5
8,	100	87	93.5	95	90	92.5	89	88	88.5	90	66	78	82	84	83	90	82	86
9,	93	89	91	94	88	91	76	89	82.5	66	91	78.5	72	47	59.5	86	80	83
10,	88	87	87.5	100	84	92	94	89	91.5	100	84	92	55	41	48	89	51	70
11,	93	87	90	73	87	80	89	100	94.5	92	92	92	55	56	55.5	58	56	57
12,	89	63	76	83	76	79.5	100	86	93	100	78	89	81	90	85.5	65	64	64.5
13,	92	76	84	100	92	96	100	96	98	88	77	82.5	73	64	68.5	78	94	86
14,	97	74	85.5	88	88	88	100	86	93	51	69	60	79	73	76	100	100	100
15,	93	86	89.5	81	50	65.5	94	100	97	82	64	73	66	52	59	94	85	89.5
16,	100	79	89.5	94	100	97	100	100	100	79	65	72	60	53	56.5	89	100	94.5
17,	93	89	91	100	92	96	100	89	94.5	66	60	63	58	45	51.5	94	90	92
18,	93	73	83	100	72	86	94	64	79	69	44	56.5	42	80	61	94	69	81.5
19,	100	95	97.5	94	100	97	100	74	87	67	48	57.5	72	84	78	81	78	79.5
20,	100	89	94.5	100	100	100	87	86	86.5	64	67	65.5	70	93	81.5	82	86	84
21,	90	90	90	95	100	97.5	100	100	100	76	60	68	93	94	93.5	82	95	88.5
22,	89	95	92	93	89	91	84	92	88	63	63	63	85	60	72.5	81	55	68
23,	100	91	95.5	66	84	75	94	100	97	79	57	68	69	70	69.5	67	74	70.5
24,	92	100	96	75	90	82.5	100	86	93	93	100	96.5	69	74	71.5	94	94	94
25,	100	82	91	100	86	93	87	58	72.5	93	87	90	94	89	91.5	88	94	91
26,	100	89	94.5	100	80	90	68	88	78	70	63	66.5	81	62	71.5	86	90	88
27,	93	76	84.5	89	76	82.5	84	83	83.5	81	76	78.5	67	63	65	70	75	72.5
28,	93	76	84.5	90	92	91	77	63	70	93	88	90.5	85	61	73	95	76	85.5
29,	94	92	93	100	91	95.5	100	87	93.5	100	84	92	70	67	68.5	76	53	64.5
30,	91	88	89.5	.....	.....	.....	100	54	77	67	57	62	82	74	78	69	67	68
31,	90	91	90.5	.....	.....	.....	76	60	68	.....	.....	.....	84	84	84	.....	.....	.....
Means.	93.9	86.5	90.2	91.1	87.3	89.2	91.5	82.9	87.2	80.3	73.9	77.1	74.3	69.6	72.0	82.8	78.3	80.5

Atmospheric Humidity—Continued.

Dates.	July.			August.			September.			October.			November			December.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8. p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1, ...	74	74	74	61	80	70.5	60	71	65.5	87	77	82	63	65	64	85	86	85.5
2, ...	82	70	76	90	77	73.5	81	67	74	80	80	80	69	61	65	100	85	92.5
3, ...	74	78	76	90	74	82	76	95	85.5	100	87	93.5	85	71	78	100	100	100
4, ...	95	95	95	86	74	80	94	88	91	86	93	89.5	76	94	85	86	100	93
5, ...	91	82	86.5	78	69	73.5	77	94	85.5	93	93	93	94	66	80	91	61	76
6, ...	90	86	88	76	72	74	88	74	81	100	100	100	66	85	75.5	61	78	69.5
7, ...	90	69	79.5	79	91	85	82	78	80	71	69	70	91	74	82.5	70	84	77
8, ...	79	89	84	87	83	85	93	72	82.5	84	76	80	64	70	67	100	100	100
9, ...	86	76	81	87	70	78.5	88	75	81.5	90	84	87	79	89	84	82	61	71.5
10, ...	68	78	73	78	79	78.5	85	71	78	90	85	87.5	100	69	84.5	76	66	71
11, ...	70	70	70	74	74	74	82	61	71.5	84	79	81.5	92	86	89	83	74	78.5
12, ...	73	74	73.5	.....	95	.....	90	100	95	100	100	100	85	83	84	90	66	78
13, ...	82	78	80	95	95	95	95	95	95	100	92	96	100	89	94.5	63	68	65.5
14, ...	90	95	92.5	81	77	79	95	86	90.5	93	79	86	89	100	94.5	89	79	84
15, ...	86	82	84	90	74	82	95	85	90	79	81	80	69	61	65	50	61	55.5
16, ...	75	79	77	86	74	80	82	79	80.5	81	73	77	69	67	68	91	88	89.5
17, ...	78	84	81	58	64	61	95	85	90	92	85	88.5	64	83	73.5	86	90	88
18, ...	87	72	78	78	78	78	76	81	82.5	100	82	91	88	73	80.5	72	82	77
19, ...	76	73	74.5	71	78	74.5	100	63	81.5	80	81	80.5	73	72	72.5	76	76	76
20, ...	86	95	90.5	87	70	78.5	72	70	71	92	100	96	76	90	83	100	87	93.5
21, ...	86	87	86.5	79	89	84	96	73	84.5	86	73	79.5	90	100	95	100	90	95
22, ...	86	86	86	76	95	85.5	88	79	83.5	82	77	79.5	82	80	81	87	88	87.5
23, ...	70	71	70.5	91	95	93	75	66	70.5	90	100	95	79	83	81	87	100	93.5
24, ...	94	90	92	85	76	80.5	68	70	69	83	73	78	92	87	89.5	100	84	92
25, ...	70	72	71	84	76	80	93	56	74.5	81	75	78	100	83	91.5	85	83	84
26, ...	80	86	83	81	74	77.5	78	54	66	81	57	69	100	79	89.5	83	89	89
27, ...	86	95	90.5	54	60	57	78	76	77	84	81	82.5	84	75	79.5	100	93	96.5
28, ...	91	82	86.5	77	68	72.5	94	84	89	92	83	87.5	100	91	95.5	100	87	93.5
29, ...	82	83	82.5	82	89	85.5	89	90	89.5	88	79	83.5	78	78	78	100	82	91
30, ...	78	95	86.5	83	63	73	69	93	81	84	89	86.5	86	86	86	100	100	100
31, ...	76	75	75.5	94	63	78.5	.....	.....	.....	71	50	60.5	.....	.....	.....	92	91	91.5
Means.	81.6	81.3	81.4	78	77.3	77.7	84.5	77.7	81.1	87.2	81.7	84.5	82.8	79.7	81.3	86.4	83.2	85.0

Meteorological Records for 1896—Precipitation in Inches—Rain and Snow.

Dates.	January.		February.		March.		April.		May.	June.
	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Total precipitation.
1,	trace	trace	.27	0	.10	trace	.07	00	00	00
2,	00	00	00	00	00	00	.05	00	trace	00
3,	trace	trace	.30	1.00	00	00	trace	trace	.02	00
4,	00	00	.10	2.00	00	00	00	00	00	.49
5,	00	00	trace	trace	00	00	00	00	00	00
6,	00	00	1.02	00	00	00	00	00	00	.39
7,	trace	trace	00	00	.11	00	00	00	00	.74
8,	00	00	00	00	trace	trace	00	00	.13	.26
9,	.01	.50	.36	6.00	00	00	.08	00	00	.22
10,	00	00	trace	trace	.10	.75	.06	00	00	.09
11,	00	00	00	00	.20	3.00	.17	00	00	00
12,	00	00	00	00	.10	2.00	.13	00	.04	00
13,	00	00	.66	.50	00	00	00	00	00	.68
14,	00	00	trace	trace	00	00	00	00	00	.23
15,	00	00	00	00	.30	3.00	00	00	00	00
16,	00	00	00	00	.18	1.80	00	00	00	.29
17,	00	00	00	00	.09	.90	00	00	00	00
18,	00	00	00	00	00	00	00	00	.01	00
19,	.15	1.00	.10	2.00	.95	4.50	00	00	.08	00
20,	00	00	00	00	trace	trace	trace	00	trace	00
21,	00	00	00	00	00	00	.50	00	.23	.67
22,	00	00	00	00	00	00	trace	00	00	.01
23,	.15	1.50	00	00	.13	2.00	00	00	00	00
24,	1.02	00	trace	trace	00	00	.40	00	00	.72
25,	.03	00	00	00	00	00	00	00	trace	.01
26,	00	00	.13	.50	.23	00	00	00	.14	00
27,	00	00	00	00	00	00	.01	00	00	00
28,	00	00	.01	00	00	00	00	00	.25	.22
29,	00	00	.71	00	.33	00	00	00	.02	00
30,	00	00	.....	.....	00	00	00	00	.02	00
31,	trace	00	.....	.....	00				.43	
Means.	1.36	3.00	3.66	12.00	2.82	17.95	1.47	trace.	1.37	5.02

Rain and Snow—Continued.

Dates.	July.	August.	September.	October.	November.		December.	
	Total precipitation.	Total precipitation.	Total precipitation.	Total precipitation.	Total precipitation.	Snow.	Total precipitation.	Snow.
1.	00	00	00	00	00	00	00	00
2.	00	.40	00	00	00	00	00	00
3.	00	00	00	00	00	00	00	00
4.	.43	00	00	00	.16	00	00	00
5.	.17	00	.48	00	1.43	00	00	00
6.	00	00	.06	trace	00	00	00	00
7.	00	.07	00	.46	00	00	00	00
8.	.09	.02	00	00	00	00	.41	00
9.	97	trace	00	00	00	00	.28	00
10.	00	trace	00	00	00	00	00	00
11.	00	00	00	00	.42	00	00	00
12.	00	.45	.15	1.31	.04	00	00	00
13.	04	.13	.03	.23	trace	trace	00	00
14.	.03	.01	00	.20	00	00	00	00
15.	.03	00	.27	00	00	00	00	00
16.	.41	.02	00	trace	00	00	00	00
17.	00	00	trace	trace	trace	00	00	00
18.	00	00	00	.11	00	00	trace	trace
19.	00	00	.98	00	00	00	trace	trace
20.	54	00	00	.43	00	00	00	00
21.	24	00	00	.02	42	00	00	00
22.	00	.10	.08	00	.10	00	20	2.0
23.	00	.22	00	.34	00	00	.05	0.5
24.	.77	.02	00	18	trace	00	00	00
25.	00	00	00	00	.02	00	00	00
26.	00	00	00	00	00	00	00	00
27.	.60	00	00	00	.02	00	00	00
28.	.15	00	.06	00	.49	00	00	00
29.	00	00	.51	00	.01	00	.05	00
30.	1.09	00	2.40	00	00	00	05	00
31.	trace	.12	.....	00	00	00	00	00
Means.	5.56	1.56	5.02	3.29	3.11	trace	1.04	2.5

Meteorological Records for 1896—Cloudiness. (On a Scale of 10.)

Dates.	January.			February.			March.			April.			May.			June		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1,	10	5	7.5	10	10	10	10	10	10	10	10	10	10	10	10	3	2	2.5
2,	2	10	6	4	10	7	10	10	10	10	10	10	10	10	10	0	0	0
3,	10	4	7	10	10	10	10	2	6	6	10	8	10	2	6.5	4	7	5.5
4,	2	0	1	10	10	10	0	0	0	9	10	9.5	0	1	0.5	10	2	6
5,	1	0	0.5	10	10	10	0	0	0	0	0	0	10	9	9.5	10	3	6.5
6,	7	10	8.5	10	10	10	10	10	10	7	1	4	4	1	2.5	9	2	5.5
7,	10	10	10	10	4	7	9	10	9.5	10	0	5	10	1	5.5	10	7	8.5
8,	1	10	5.5	10	10	10	10	10	10	0	0	0	10	2	6	6	10	8
9,	10	10	10	10	10	10	9	0	4.5	1	10	5.5	0	2	1	8	10	9
10,	10	10	10	9	7	8	10	0	10	10	10	10	0	6	3	10	0	5.5
11,	10	5	7.5	3	4	3.5	10	10	10	10	10	10	0	8	4	0	0	0
12,	10	1	5.5	0	3	1.5	10	0	5	10	0	5	8	10	9	0	5	2.5
13,	1	10	5.5	10	10	10	2	0	1	5	4	4.5	2	3	2.5	10	10	10
14,	10	10	10	10	0	5	9	2	5.5	10	4	7	10	10	10	10	8	9
15,	10	2	6	1	4	2.5	10	10	10	4	2	3	1	0	0.5	10	10	10
16,	1	0	0.5	10	0	5	10	10	10	6	1	3.5	0	3	1.5	10	10	10
17,	10	10	2.5	0	0	0	3	0	1.5	6	2	4	5	0	2.5	10	1	5.5
18,	8	10	9	1	10	5.5	8	10	9	2	3	2.5	4	2	3	5	3	4
19,	10	10	10	10	5	7.5	10	10	10	8	10	9	7	9	8	1	5	3
20,	10	10	10	3	10	6.5	8	8	8	0	10	5	10	10	10	7	3	5
21,	10	10	10	7	10	8.5	2	5	4	10	10	10	10	10	10	6	9	7.5
22,	10	10	10	2	4	3	10	0	5	4	0	2	10	2	6	7	1	4
23,	10	10	10	10	10	10	10	1	5.5	0	5	2.5	10	6	8	8	7	7.5
24,	10	10	10	10	8	9	0	0	0	10	10	10	10	1	5.5	10	10	10
25,	10	10	10	2	1	1.5	0	3	1.5	10	10	10	10	10	10	10	10	10
26,	10	10	10	10	10	10	10	10	10	6	5	5.5	10	4	7	4	1	2.5
27,	4	1	2.5	5	0	2.5	4	8	6	10	10	10	2	5	3.5	9	7	8
28,	0	0	0	2	10	6	2	10	6	10	8	9	10	3	6.5	10	1	5.5
29,	0	7	3.5	10	10	10	10	10	10	10	2	6	9	0	4.5	1	0	0.5
30,	4	10	7	.....	.....	.....	10	1	5.5	7	10	8.5	10	10	10	0	0	0
31,	10	10	10	.....	.....	.....	2	0	4	.....	.....	.....	8	4	6	.....	.....	.....
Means,	7.0	6.9	7.0	6.9	6.9	6.9	7.3	5.5	6.4	6.7	5.9	6.3	6.8	5.0	5.9	6.6	4.8	5.7

Cloudiness—Continued.

Dates.	July			August			September.			October.			November.			December.		
	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.	8 a. m.	8 p. m.	Mean.
1.	1	0	0.5	6	10	8	1	0	0.5	10	10	10	9	0	4.5	9	10	9.5
2.	1	1	1	10	0	5	6	0	3	8	0	4	0	0	0	4	8	6
3.	2	2	2	5	1	3	8	7	7.5	10	10	10	5	5	5	1	0	0.5
4.	10	10	10	1	1	1	0	0	0	10	10	10	10	10	10	4	10	7
5.	10	8	9	2	0	1	10	10	10	10	0	5	10	1	5.5	9	2	5.5
6.	10	4	7	0	1	0.5	9	0	4.5	10	10	10	10	0	5	1	1	1
7.	10	5	7.5	8	9	8.5	0	0	0	8	10	9	0	10	5	10	4	7
8.	10	10	10	4	7	5.5	10	0	5	10	0	5	10	10	10	10	10	10
9.	10	9	9.5	9	9	9	0	0	0	1	0	0.5	2	2	2	10	8	9
10.	4	6	5	8	10	9	0	0	0	1	0	0.5	3	9	6	10	5	7.5
11.	0	1	0.5	3	2	2.5	3	4	3.5	10	4	7	10	0	5	9	10	9.5
12.	1	3	2	0	9	4.5	3	10	6.5	10	10	10	10	3	6.5	1	1	1
13.	3	10	6.5	10	10	10	10	2	6	10	10	10	10	2	6	4	2	3
14.	10	10	10	0	1	0.5	10	10	10	10	10	10	9	0	4.5	1	0	0.5
15.	10	10	10	6	1	3.5	10	10	10	1	3	2	9	0	4.5	10	10	10
16.	4	3	3.5	10	9	9.5	2	1	1.5	6	10	8	7	0	3.5	10	0	5
17.	0	0	0	0	0	0	10	0	5	10	10	10	6	9	7.5	0	8	4
18.	1	1	1	7	4	5.5	6	9	7.5	10	8	9	4	4	4	10	10	10
19.	3	10	6.5	1	0	0.5	10	4	7	5	2	3.5	9	1	5	9	10	9.5
20.	10	10	10	9	10	9.5	3	0	1.5	10	10	10	8	10	9	3	10	6.5
21.	10	10	10	10	10	10	3	10	9	9	8	8.5	10	10	10	10	6	8
22.	7	9	8	0	10	5	10	10	10	0	9	4.5	10	0	5	10	10	10
23.	0	10	5	10	10	10	2	0	1	2	10	6	1	4	2.5	10	0	5
24.	10	10	10	10	5	7.5	1	1	1	3	9	6	10	10	10	0	0	0
25.	0	1	0.5	0	0	0	3	10	6.5	1	0	0.5	10	10	10	9	4	6.5
26.	1	2	1.5	0	10	5	8	1	4.5	0	0	0	5	8	6.5	10	10	10
27.	9	8	8.5	0	0	0	8	10	9	1	0	0.5	4	10	7	10	0	5
28.	10	1	5.5	1	0	0.5	10	10	10	10	9	9	10	10	10	1	2	1.5
29.	1	10	5.5	0	0	0	10	10	10	9	2	5.5	9	10	9.5	9	10	9.5
30.	4	4	4	0	8	4	3	10	6.5	10	3	6.5	9	1	5	10	10	10
31.	9	1	5	10	0	5	.....	.....	.....	0	1	0.5	.....	.....	.....	10	0	5
Means	5.3	5.8	5.6	4.5	4.7	4.6	5.8	4.6	5.2	6.6	5.8	6.2	7.3	5.6	6.2	6.9	5.5	6.2

Meteorological Records for 1896—Wind.

Dates.	January.							February.						
	Direction.		Velocity in miles per hour.		Anemometer record.			Direction.		Velocity in miles per hour.		Anemometer record.		
	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.
1.	W	W	8	10	30	110	150	SW	W	0	4	490	490	0
2.	W	S	2	4	115	155	45	W	E	11	3	160	230	240
3.	W	W	10	14	205	325	170	E	W	3	0	230	230	0
4.	W	W	13	11	465	90	265	E	E	2	0	230	230	0
5.	SW	W	4	6	145	235	145	E	NE	0	0	230	230	0
6.	E	SE	4	4	245	250	15	E	NW	4	28	230	320	90
7.	S	S	3	4	300	330	80	W	W	24	10	35	185	365
8.	E	E	4	0	355	355	25	NW	E	3	4	250	260	75
9.	S	W	4	5	360	380	25	E	W	0	8	260	330	70
10.	E	NE	4	5	410	410	30	W	W	6	4	420	485	155
11.	NE	SW	0	0	410	410	0	W	W	18	30	100	305	320
12.	SW	W	4	10	410	445	35	N	N	10	0	435	455	150
13.	W	W	2	2	5	30	85	S	W	0	10	455	470	15
14.	NW	NW	11	10	90	220	190	W	W	7	3	70	200	230
15.	NW	E	9	0	295	345	125	S	W	8	4	210	280	80
16.	S	SW	1	0	345	365	20	N	NW	10	12	375	50	270
17.	E	E	2	1	365	365	0	N	E	9	5	170	175	125
18.	E	S	0	0	370	370	5	E	W	2	3	175	210	35
19.	S	E	0	1	370	370	0	S	SW	5	10	260	380	170
20.	E	S	4	0	370	375	5	W	W	10	20	490	110	230
21.	S	W	0	1	375	375	0	W	W	4	5	180	315	205
22.	E	E	4	3	375	375	0	W	W	3	3	365	425	110
23.	E	E	5	12	385	390	15	W	SW	6	5	455	30	105
24.	E	N	6	0	390	395	5	W	W	12	5	135	335	305
25.	W	W	3	2	410	455	60	NW	W	13	3	500	150	315
26.	W	W	7	14	480	80	125	S	W	3	11	165	240	90
27.	W	W	12	0	190	285	205	W	S	2	0	265	325	85
28.	W	W	9	0	350	370	85	W	S	0	0	325	350	25
29.	W	S	1	0	375	395	25	NE	NE	9	6	350	370	20
30.	W	N	2	4	405	460	65	.....	.....	.....	.....	.....	.....	.....
31.	NE	S	1	3	465	490	30	.....	.....	.....	.....	.....	.....	.....
Total movement,	.....	.....	.....	.....	.....	.....	2,630	.....	.....	.....	.....	.....	.....	3 880
Prevailing direction,	W	W	.....	.....	.....	.....	.....	W	W	.....	.....	.....	.....	.....

Wind—Continued.

Dates	March. Direction.		March. Velocity in miles per hour.		March. Anemometer record.			April. Direction.		April. Velocity in miles per hour.		April. Anemometer record.		
	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.
1.	W	SW	10	15	425	45	175	E	E	0	0	320	320	0
2.	W	NW	12	27	230	480	435	W	W	5	10	355	500	180
3.	W	NW	14	22	165	360	380	W	W	12	14	105	310	310
4.	W	W	10	5	10	210	350	W	W	18	17	10	240	430
5.	W	N	15	1	345	495	285	W	W	10	0	370	465	225
6.	NE	S	0	0	495	5	10	SW	NW	4	20	470	140	175
7.	SW	W	7	13	10	165	160	NW	E	6	0	180	260	120
8.	W	W	11	16	275	445	285	E	E	6	0	300	320	30
9.	W	NW	10	5	55	200	255	S	S	2	2	320	440	120
10.	NE	W	0	1	200	200	0	SW	E	3	5	480	480	40
11.	E	N	10	3	200	200	0	W	W	2	1	490	500	20
12.	W	W	11	6	330	475	275	W	S	0	5	0	40	40
13.	W	W	5	1	5	85	110	S	S	2	4	45	75	35
14.	W	W	3	0	95	165	80	S	W	9	0	120	180	105
15.	E	E	2	1	165	165	0	S	S	3	1	180	235	55
16.	E	NW	0	1	165	170	5	S	SW	3	1	240	285	50
17.	NW	W	7	3	295	375	205	W	W	1	1	290	325	40
18.	SW	S	1	4	385	425	50	W	W	1	1	325	405	85
19.	NE	W	1	4	455	475	70	SW	W	2	4	405	495	90
20.	W	NW	21	3	155	330	355	S	W	0	0	15	60	65
21	SE	S	2	6	420	360	30	W	W	6	6	90	190	130
22.	W	S	8	4	5	60	200	N	W	12	2	340	455	265
23.	NE	N	9	3	75	75	15	N	W	1	1	460	470	15
24.	NE	N	1	1	75	80	5	W	E	0	0	475	475	5
25.	W	S	6	5	100	175	95	E	S	5	0	475	490	15
26.	S	W	1	8	200	290	115	S	S	4	6	490	25	35
27.	W	W	12	4	30	125	335	S	S	5	3	50	135	110
28.	W	S	1	6	125	180	55	S	E	10	8	175	210	75
29.	S	S	1	4	235	240	60	E	E	1	0	210	210	0
30.	S	W	0	8	270	300	60	SE	SE	8	5	225	325	115
31.	W	W	5	0	305	320	20							
Total movement.							3,895							3,005
Prevailing direction.	W	W						SW	W					

Wind—Continued.

Dates.	May.							June.						
	Direction.		Velocity in miles per hour.		Anemometer record			Direction.		Velocity in miles per hour.		Anemometer record		
	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.
1	S	S	2	1	275	410	50	N	N	8	2	25	150	40
2	SE	E	4	4	425	435	25	N	N	2	2	155	170	130
3	S	W	2	3	435	470	35	E	S	1	6	170	220	50
4	W	W	2	1	480	500	30	W	W	10	2	225	235	15
5	W	NW	1	5	5	100	100	E	S	1	1	235	245	10
6	E	E	1	0	105	110	10	E	W	1	0	245	250	5
7	E	W	7	0	110	135	25	W	E	1	2	255	270	20
8	N	W	0	0	135	150	15	W	S	1	5	270	345	75
9	S	N	3	3	150	275	125	W	N	4	3	350	380	35
10	N	NW	3	11	280	445	170	N	W	7	8	400	5	125
11	W	W	12	2	485	135	190	W	W	3	6	50	230	225
12	S	W	2	2	160	175	40	W	W	5	0	260	310	80
13	NE	E	6	4	180	200	25	W	NE	3	0	315	315	5
14	S	S	5	0	215	250	50	NE	N	0	0	315	320	5
15	W	W	12	0	300	410	160	N	S	1	2	330	340	20
16	SW	S	3	0	455	480	70	E	S	4	2	340	390	50
17	W	W	7	0	485	90	110	S	W	1	2	390	390	0
18	SW	W	10	2	120	170	80	NE	NE	1	1	390	390	0
19	W	W	7	1	180	250	80	E	N	0	3	395	420	30
20	E	E	6	4	250	260	10	W	W	1	0	420	430	10
21	E	E	5	0	275	280	20	S	W	3	0	430	455	25
22	S	W	5	7	290	345	65	W	W	3	10	10	40	85
23	E	E	4	4	360	360	15	NE	W	8	1	65	70	30
24	E	W	0	0	360	410	50	S	E	1	5	70	80	10
25	S	S	6	8	410	455	45	E	E	3	0	80	80	0
26	SW	SW	5	6	30	75	120	S	W	5	4	95	190	110
27	W	W	3	1	75	120	45	E	S	4	0	205	210	20
28	S	S	9	8	130	195	75	S	..	2	4	220	235	25
29	W	W	4	1	225	345	150	S	NW	4	8	250	330	195
30	S	W	2	2	350	395	50	W	W	2	3	330	345	15
31	NW	NW	5	6	400	485	90	.....	.....	.....	.....	.....	.....	.....
Total movement	.....	.....	.....	.....	.....	.....	2,110	WE	W	.....	.....	.....	.....	.....
Prevailing direction	SW	W	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,360

Wind—Continued.

Dates	July. Direction. 8 a. m.	July. Direction. 8 p. m.	July. Velocity in miles per hour. 8 a. m.	July. Velocity in miles per hour. 8 p.m.	July. Anemometer record. 8 a. m.	July. Anemometer record. 8 p. m.	July. Anemometer record. Daily movement.	August. Direction. 8 a. m.	August. Direction. 8 p. m.	August. Velocity in miles per hour. 8 a. m.	August. Velocity in miles per hour. 8 p.m.	August. Anemometer record. 8 a. m.	August. Anemometer record. 8 p. m.	August. Anemometer record. Daily movement.
1.	W	W	2	1	345	355	0	S	S	6	3	45	80	0
2.	SW	SW	0	6	355	390	35	W	W	2	3	90	150	70
3.	SW	SW	1	2	390	405	15	W	W	1	0	150	155	5
4.	W	SW	0	1	405	440	35	W	W	0	2	155	175	20
5.	S	W	0	1	440	480	40	S	W	3	1	175	190	15
6.	E	W	0	0	500	500	20	S	W	3	2	190	215	25
7.	N	NW	2	8	5	90	90	S	W	2	0	215	220	5
8.	N	NE	1	1	95	95	5	W	SW	1	2	225	230	10
9.	S	S	7	5	100	220	125	S	S	4	3	235	270	40
10.	W	S	4	0	225	275	55	W	W	2	3	275	300	30
11.	W	W	2	3	280	315	40	SW	W	3	1	305	335	35
12.	S	W	3	1	320	340	25	N	W	2	1	335	355	20
13.	W	W	6	5	340	350	10	N	W	2	1	355	355	0
14.	W	W	4	0	350	355	5	N	W	4	1	365	360	5
15.	SW	W	5	3	360	360	5	W	W	2	1	360	360	0
16.	N	N	6	2	385	420	60	W	W	4	6	365	385	25
17.	N	N	3	1	420	420	0	N	N	8	7	410	465	80
18.	E	E	3	0	420	420	0	W	N	4	2	465	500	35
19.	S	S	5	2	450	495	75	N	N	10	1	5	50	50
20.	SW	W	4	3	500	15	20	E	E	2	2	50	50	0
21.	W	W	1	0	15	15	0	S	S	3	3	65	65	15
22.	W	W	4	0	15	30	15	S	S	3	1	90	95	30
23.	NW	W	8	2	45	120	90	S	S	3	0	100	130	35
24.	NE	W	2	6	120	125	5	N	N	2	3	140	150	20
25.	N	W	8	3	225	285	160	N	S	6	5	150	160	10
26.	S	S	2	1	295	305	20	S	S	7	8	165	250	90
27.	W	W	1	6	310	360	55	NE	N	8	1	295	415	165
28.	SW	S	2	1	365	375	15	NE	NE	3	1	420	440	25
29.	W	W	1	0	375	400	25	W	W	2	5	440	450	10
30.	W	W	4	2	420	470	70	W	W	3	3	450	490	40
31.	N	N	8	2	15	45	75	W	NW	1	6	5	55	65
Total movement,							1,210							1,010
Prevailing direction,	W	W						W	W					

Wind—Continued.

Dates	September.							October.						
	Direction.		Velocity in miles per hour.		Anemometer record.			Direction.		Velocity in miles per hour.		Anemometer record.		
	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.
1	N	W	3	1	95	140	85	W	W	5	12	65	135	90
2	W	S	0	2	140	225	85	N	NE	8	1	175	200	65
3	SW	N	0	8	230	325	100	N	NE	3	4	205	205	5
4	N	N	2	2	355	360	35	NE	NE	6	2	205	205	0
5	SE	SE	8	0	382	431	71	NE	NE	3	0	210	210	5
6	W	W	2	3	440	490	59	E	E	2	1	210	210	0
7	W	E	0	1	495	10	20	N	W	10	12	260	365	155
8	E	E	1	1	15	15	5	W	N	6	2	385	450	85
9	W	W	1	0	15	45	30	N	E	3	2	450	455	5
10	NE	NW	5	4	45	105	60	NE	E	3	2	460	465	10
11	SW	S	4	5	110	120	15	NE	NE	5	4	465	470	5
12	E	NE	3	0	120	140	20	NE	NE	5	4	470	470	0
13	NE	NE	7	1	140	140	0	NE	NE	5	5	475	480	10
14	E	S	1	3	140	150	10	N	NW	3	3	485	70	90
15	NE	NE	1	3	150	150	0	SW	W	3	4	80	135	65
16	NE	E	6	1	150	150	0	W	W	4	4	135	215	80
17	E	W	1	1	155	200	50	SW	SW	3	2	215	225	10
18	SW	S	2	0	200	220	20	W	W	1	2	225	270	45
19	W	W	2	10	240	355	135	W	W	2	1	295	310	40
20	N	W	8	2	470	5	150	W	W	4	3	325	350	40
21	N	S	3	3	5	15	10	S	W	3	2	355	430	80
22	S	N	1	13	15	80	65	SW	SW	2	1	435	455	25
23	N	W	9	5	175	245	165	S	SE	1	0	455	460	5
24	W	W	4	1	250	285	40	NW	W	6	0	475	105	145
25	S	S	0	2	285	345	60	W	W	5	1	105	110	5
26	W	S	1	4	345	380	35	S	S	2	2	110	120	10
27	S	S	1	0	380	425	45	S	S	2	2	120	130	10
28	NE	NE	8	9	430	440	15	E	W	2	3	130	130	0
29	E	E	10	15	440	455	15	W	W	1	2	130	155	25
30	W	W	6	6	10	45	90	S	S	3	2	160	180	25
31								S	NW	4	5	195	225	45
Total movement							1,460							1,180
Prevailing direction	W-E	W						NW	W					

Wind—Continued.

Dates.	November.							December.						
	Direction.		Velocity in miles per hour.		Anemometer record			Direction.		Velocity in miles per hour.		Anemometer record		
	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.	8 a. m.	8 p. m.	8 a. m.	8 p.m.	8 a. m.	8 p. m.	Daily movement.
1,	SW	SW	2	4	225	240	15	W	W	7	3	335	390	30
2,	SW	S	3	2	240	240	0	E	NE	3	3	410	410	20
3,	E	E	2	5	245	245	5	N	W	3	3	410	430	20
4,	S	E	6	2	255	280	35	S	S	5	7	420	480	50
5,	E	W	3	7	320	370	90	SW	SW	5	8	485	495	15
6,	W	W	6	3	485	60	190	S	W	5	1	5	30	35
7,	S	W	3	5	65	85	25	S	W	2	6	30	35	5
8,	W	W	10	12	120	210	125	N	NE	2	2	35	35	0
9,	W	W	8	3	260	330	120	W	W	10	12	90	185	150
10,	S	S	1	11	330	365	35	W	W	10	11	320	365	180
11,	S	W	3	2	410	420	55	NW	W	9	5	465	5	140
12,	W	W	5	3	425	435	15	W	W	1	1	5	5	0
13,	S	W	2	25	435	70	135	SW	SW	4	3	10	45	40
14,	NW	W	8	1	250	295	225	W	N	2	2	70	70	25
15,	W	W	3	2	260	325	40	NE	E	3	10	75	75	5
16,	W	W	4	6	350	370	35	NE	N	11	5	85	265	190
17,	S	W	8	3	380	385	15	E	E	3	2	280	285	25
18,	S	S	2	4	390	410	25	W	W	3	4	310	320	45
19,	NW	E	10	7	445	40	130	W	NE	9	4	493	130	300
20,	E	E	9	5	50	50	10	SW	W	3	5	130	145	15
21,	S	SW	5	3	80	120	70	S	W	3	12	145	195	50
22,	W	N	6	3	200	240	120	S	S	4	4	220	250	55
23,	S	S	6	4	255	290	50	W	W	12	15	290	450	200
24,	SW	W	2	5	305	340	50	W	W	8	12	25	130	180
25,	W	S	2	3	345	360	20	W	W	5	1	195	240	110
26,	S	S	1	8	370	415	55	W	W	8	6	265	320	80
27,	SW	S	8	4	490	25	110	NE	NE	8	2	345	345	125
28,	N	NW	4	10	40	65	40	E	W	2	2	345	350	5
29,	NW	W	4	4	115	150	85	S	S	3	2	350	350	0
30,	W	W	4	4	195	300	150	S	S	3	2	350	380	30
31,								W	W	3	1	405	405	25
Total movement,							2,075							2,105
Prevailing direction,	W	W						W	W					

Soil Temperature Records for 1896—January.

Dates.	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1	24	25	24	24.3	1	30	30	29.5	29.7	0.5	33.5	33.5	33	33.3	0.5
2	22	40	25	28	18	28	32.5	32	31.1	4.5	33	33	33	33	0
3	30	25	18	22.7	12	32	30	27.5	29.3	4.5	33	33	33	33	0
4	8	14	8	9.5	6	21	22.5	20.5	21.1	2	31.5	30.5	29	30	2.5
5	8	15	8	9.7	7	19	22	20	20.3	3	26.5	27.5	26.5	26.7	1
6	10	22	18	17	12	19	26	24	23.3	7	25	28.5	28	27.4	3.5
7	20	24	24	23	4	24	26.5	27.5	26.4	3.5	27.5	28.5	28.5	28.3	1
8	16	27	28	24.7	12	23.5	28.5	28	27	5	28	29.5	30	29.4	2
9	25	30	30	28.7	5	27	29.5	30	29.1	3	29	30	30	29.7	1
10	27	30	25	26.7	5	29.5	30.5	28.5	29.3	2	30.5	31	31	30.9	1
11	25	32	23	25.7	9	27.5	31	27.5	28.4	3.5	30	30.5	30.5	30.4	0.5
12	28	38	30	31.5	10	28.5	31	31	30.4	2.5	29.5	30.5	31.5	30.7	2
13	19	30	25	24.7	11	24.5	28.5	28	27.3	4.5	28.5	29.5	30	29.5	1.5
14	22	28	23	24	6	25	27	26	26	2	28.5	29.5	29	29	1
15	22	30	21	23.5	9	26	29	27	27.3	3	28.5	29	30	29.4	1.5
16	14	35	24	24.3	21	21.5	31.5	28.5	27.5	10	26.5	30	31	29.6	4.5
17	20	35	22	27.3	15	25	31	28.5	28.3	6	28.5	30	31	30.1	2.5
18	24	41	33	32.7	17	26	32.5	32	30.6	6.5	29	31	31	30.5	2
19	32	32	32	32	0	31.5	32	32	31.9	0.5	32	31.5	32	31.9	0.5
20	32	32	30	31	2	32	32	32	32	0	32	32	32	32	0
21	31	32	30	30.7	2	31	32	32	31.7	1	31.5	32	32	31.9	0.5
22	30	33	32	31.7	3	30.5	31.5	31.5	31.3	1	31.5	31.5	31.5	31.5	0
23	32	32	34	33	2	31	31.5	32	31.6	1	31.5	31.5	32	31.7	0.5
24	34	35	34	34.3	1	32	32	32	32	0	32	32	32	32	0
25	33	35	33	33.5	2	32	32.5	32	32.1	0.5	32	32	32	32	0
26	33	34	30	31.7	4	32	32	32	32	0	32	32	32	32	0
27	24	30	25	26	6	31	31	30	30.5	1	32	32	32	32	0
28	24	38	38	34.5	18	29	32	32	31.7	3	32	32	32	32	0
29	25	44	32	33.3	19	29	32	32	31.7	3	32	32	32	32	0
30	32	14	37	37.5	12	32	33	32.5	32.5	1	32	32	32	32	0
31	32	36	34	34	4	32	32.5	32	32.1	0.5	32	32	32	32	0
Means	24.5	30.2	26.8	27.4	8.23	27.8	30.2	29.4	29.2	2.76	30.4	31.0	31.0	30.9	0.95

Soil Temperature—January—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m	8 p. m.	Mean.	Range.	8 a. m.	2 p. m	8 p. m.	Mean	Range.
1.	34.5	34	34	34.1	0.5	36.5	36.5	36	36.3	0.5	39	39	39	39	[illegible]
2.	34	34	34	34	0	36	36	36	36	0	39	38.5	38.5	38.6	0.5
3.	33.5	33.5	33.5	33.5	0	36	36	36	36	0	38.5	38.5	38.5	38.5	[illegible]
4.	33	33	32.5	32.7	0.5	35	35	35	35	0	38	38	38	38	[illegible]
5.	32	30.5	30.5	31.3	1.5	34.5	34.5	34.5	34.5	0	37.5	37.5	37.5	37.5	[illegible]
6.	29	30	30	29.7	1	34	34	34	34	0	37.5	37.5	37.5	37.5	[illegible]
7.	30	30	30	30	0	33.5	33.5	33.5	33.5	0	37	37	37	37	[illegible]
8.	30	30	31	30.5	1	33.5	33.5	33.5	33.5	0	36.5	36.5	36.5	36.5	[illegible]
9.	30.5	30.5	31	30.7	0.5	33	33	33	33	0	36.5	36.5	36.5	36.5	[illegible]
10.	31	31	31.5	31.3	0.5	33.5	33.5	33.5	33.5	0	36.5	36.5	36.5	36.5	[illegible]
11.	31	31	31	31	0	33.5	33	33	33.1	0.5	36	36	36	36	[illegible]
12.	30.5	31	31.5	31.1	1	33	33	33	33	0	36	36	36	36	[illegible]
13.	31	30.5	31	30.9	0.5	33	33	33	33	0	36	36	36	36	[illegible]
14.	30	30.5	31	30.6	1	33	33	33	33	0	36	36	36	36	[illegible]
15.	30	30.5	31	30.6	1	33	33	33	33	0	36	36	36	36	[illegible]
16.	29	30	31	30.3	2	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
17.	30	30.5	31	30.6	1	33	32.5	32.5	32.6	0.5	35.5	35.5	35.5	35.5	[illegible]
18.	30.5	31	31	30.9	0.5	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
19.	31.5	31.5	31.5	31.5	0	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
20.	32	32	32	32	0	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
21.	31.5	32	32	31.9	0.5	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
22.	32	32	32	32	0	33	33	33	33	0	35.5	35.5	35.5	35.5	[illegible]
23.	32	31.5	31.5	31.6	0.5	33	33	33	33	0	35.5	35.5	35.5	35.1	[illegible]
24.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
25.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
26.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
27.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
28.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
29.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
30.	32	32	32	32	0	33	33	33	33	0	35	35	35	35	[illegible]
31.	32	32	32	32	0	33	33.5	33.5	33.4	0.5	35	35	35	35	[illegible]
Means.	31.4	31.5	31.7	31.6	0.44	33.5	33.5	33.5	33.5	0	35	35	35	35	0
						33.5	33.5	33.5	33.5	0.01	36.1	36.1	36.1	36.1	0.00

Soil Temperature Records for 1896—February.

Dates	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	34	47	40	40.3	13	32	43	33	35.3	11	32	32	32.5	32.5	0.5
2,	32	40	34	35	8	32	32	32	32	0	32.5	32	32	32.1	0.5
3,	30	30	30	30	0	32	32	32	32	0	32	32	32	32	0
4,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
5,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
6,	32	32	34	33	1	32	32	32	32	0	32	32	32	32	0
7,	31	33	39	35.5	8	32	32	32	32	0	32	32	32	32	0
8,	30	37	31	32.3	7	32	32	32	32	0	32	32	32	32	0
9,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
10,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
11,	31	31	31	31	0	32	32	32	32	0	32	32	32	32	0
12,	29	30	30	29.7	1	32	32	32	32	0	32	32	32	32	0
13,	31	32	32	31.7	1	32	32	32	32	0	32	32	32	32	0
14,	31	32	30	30.7	2	32	32	32	32	0	32	32	32	32	0
15,	30	32	32	31.5	2	32	32	32	32	0	32	32.5	32.5	32.4	0.5
16,	28	27	19	23.3	9	32	30	26	28.5	6	32	32	31	31.5	1
17,	12	20	18	17	8	18.5	25	24.5	23.1	6.5	26	28.5	28	27.6	2.5
18,	15	27	24	22.5	12	19	29	26.5	25.3	10	23.5	28.5	29	27.5	5.5
19,	26	28	28	27.5	2	26.5	29	29	28.4	2.5	27	29	29.5	28.7	2.5
20,	25	24	23	23.7	2	28	26	25	26	3	27.5	27.5	27.5	27.5	0
21,	23	22	22	22.3	1	24.5	24.5	24.5	24.5	0	26.5	27	27	26.9	0.5
22,	22	28	27	26	6	23.5	28	28.5	27.1	5	25.5	28	29.5	28.1	4
23,	30	34	34	33	4	30	32	32	31.5	2	29.5	31	31.5	30.9	2
24,	36	42	32	35.5	10	32	32	32	32	0	31.5	32	32	31.9	0.5
25,	18	27	20	21.3	9	25.5	27.5	26	26.3	2	30	29	28.5	29	1.5
26,	28	33	32	30.7	5	28	31	31	30.3	3	28.5	30	31	30.1	2.5
27,	29	46	33	35.3	17	28.5	32	32	31	3.5	29	31	31.5	30.7	2.5
28,	32	44	38	38	12	32	32	32	32	0	32	32	32	32	0
29,	40	40	35	37.5	5	32.5	32.5	32.5	32.5	0	32	32	32	32	0
Means,	28.7	32.6	30.2	30.4	5.00	29.7	31.1	30.4	30.4	1.66	30.4	31.0	31.1	30.9	0.95

Soil Temperature—February—Continued.

Dates	Six Inches					Twelve Inches					Twenty-four Inches				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
2	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
3,	32	32	32	32	0	33	33	33	33	0	35	35	35	35	0
4,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
5,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
6,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
7,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	34.5	34.5	34.5	34.5	0
8,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	34.5	35	35	34.9	0.5
9,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
10,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
11,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
12,	32	32	32	32	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
13,	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
14,	32.5	32.5	33	32.7	0.5	33.5	34	34	33.9	0.5	35	35	35	35	0
15,	32.5	32.5	32.5	32.5	0	34	34	34	34	0	35	35	35	35	0
16,	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0	35	35	35	35	0
17,	32	30.5	30.5	30.9	1.5	33.5	33.5	33.5	33.5	0	35	35	35	35	0
18,	27	29	30	29.9	3	33	33	33	33	0	35	35	35	35	0
19	28	29.5	30	29.3	2	33	33	33	33	0	35	35	35	35	0
20,	29	29	28.5	28.7	0.5	33	33	33	33	0	35	35	35	35	0
21,	27.5	28	28	28.1	0.5	33	33	33	33	0	35	35	35	35	0
22,	27	28	30	28.7	3	33	33	33	33	0	34.5	34.5	34.5	34.5	0
23	30	30.5	31	30.6	1	32.5	32.5	32.5	32.5	0	34.5	34.5	34.5	34.5	0
24	31.5	31.5	31.5	31.5	0	32	32.5	32.5	32.4	0.5	34.5	34.5	34.5	34.5	0
25,	31.5	30.5	30	30.5	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
26	29.5	30.5	31	30.5	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
27,	30	31	31.5	31	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
28	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
29	32	32	32	32	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
Means,	31.1	31.2	31.4	31.3	0.57	33.1	33.2	33.2	33.2	0.03	34.7	34.7	34.7	34.7	0.01

Soil Temperature Records for 1896—March.

Dates.	At Surface.					One Inch.					Three Inches				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	32	35	31	32.3	4	32	32.5	32	32.1	0.5	32	32	32	32	0
2.	26	28	24	25.5	4	31.5	31	29	30.1	2.5	32	32	32	32	0
3.	18	33	20	22.7	15	25	30	26.5	27	5	28.5	30	29.5	29.4	1.5
4.	16	32	19	21.5	16	23	29	25	25.5	6	25.5	29.5	29	28.3	4
5.	14	40	26	26.5	26	19	30	29	25.7	11	23.5	29	30.5	28.4	7
6.	28	48	37	37.5	20	28.5	32.5	32	31.3	4	29	31	31.5	30.7	2.5
7.	38	35	31	33.7	7	32	32	32	32	0	32	32	32	32	0
8.	29	31	26	28	5	30	31.5	29.5	30.1	2	31.5	31.5	31.5	31.5	0
9.	26	37	28	29.7	11	27.5	31.5	30.5	30	4	30	31	31.5	31	1.5
10.	29	31	29	29.5	2	30	31	31	30.7	1	30	31.5	31.5	31.1	1.5
11.	30	30	30	30	0	31	31	31	31	0	31.5	31.5	31.5	31.5	0
12.	30	30	30	30	0	31	31	31	31	0	31.5	31.5	31.5	31.5	0
13.	26	30	27	27.5	4	30.5	30	30	30.1	0.5	31.5	31.5	31.5	31.5	0
14.	24	28	26	26	4	27.5	29	29	28.6	1.5	29	29	29	29	0
15.	26	28	30	28.5	4	29	29	29	29	0	29.5	29.5	29.5	29.5	0
16.	30	30	30	30	0	30	30	30	30	0	31.5	31.5	31.5	31.5	0
17.	30	31	32	31.3	2	30.5	31	31.5	31.1	1	31.5	31.5	31.5	31.5	0
18.	28	32	32	31	4	30.5	31.5	31.5	31.3	1	31.5	31.5	31.5	31.5	0
19.	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
20.	29	30	30	29.7	1	30.5	30.5	29	29.7	1.5	32	31.5	31	31.4	1
21.	28	31	31	30.3	3	27	31.5	31.5	30.4	4.5	28.5	31	31	30.4	2.5
22.	32	40	37	36.5	8	32	32	32	32	0	32	32	32	32	0
23.	19	27	28	25.5	9	28	30	30.5	29.7	2.5	31.5	31	31.5	31.4	0.5
24.	22	28	25	25.5	6	29	31.5	31	30.6	2.5	30.5	31.5	31.5	31.3	1
25.	26	38	33	31.3	7	27	32	32	30.7	5	29.5	31.5	31.5	31	2
26.	35	39	26	31.5	13	32	32	32	32	0	32	32	32	32	0
27.	18	34	26	26	16	24	31	30.5	29	7	27	30.5	31	29.9	4
28.	26	45	40	37.7	19	28.5	32	32	31.1	3.5	29	31.5	31.5	30.9	2.5
29.	37	54	48	46.7	17	32	37	33.5	34	5	32	32	32	32	0
30.	42	57	40	43.7	17	34	40	35	36	6	32	32.5	33	32.6	1
31.	38	54	44	45	16	32	49.5	33.5	37.1	17.5	32	34	33.5	33.3	2
Means.	27.9	35.3	30.6	31.1	8.29	29.2	32.1	30.7	30.7	3.06	30.4	31.3	31.4	31.1	1.95

Soil Temperature—March—Continued.

Dates.	Six Inches.					Twelve Inches					Twenty four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	32	32	32	32	0	33	33	33	33	0	34	34	34	34	0
2.	32	32	32	32	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
3.	31	30.5	30.5	30.6	0.5	32.5	33	33	32.9	0.5	34	34	34	34	0
4.	27.5	30	30	29.4	2.5	33	32.5	32.5	32.6	0.5	34	34	34	34	0
5.	26	29	31	29.3	0.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
6.	30	31	31.5	31	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
7.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
8.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
9.	30	31	31.5	31	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
10.	31	31.5	31.5	31.4	0.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
11.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
12.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
13.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
14.	30	30	30	30	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
15.	30	30	30	30	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
16.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
17.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
18.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
19.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
20.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
21.	29	30.5	30.5	30.1	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
22.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
23.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
24.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
25.	31	31.5	31.5	31.4	0.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
26.	31.5	31.5	31.5	31.5	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
27.	30	30.5	31	30.6	1	32.5	32.5	32.5	32.5	0	34	34	34	34	0
28.	30	31	31	30.7	1	32.5	32.5	32.5	32.5	0	34	34	34	34	0
29.	31.5	31.5	32	31.7	0.5	32.5	32.5	33	32.7	0.5	34	34	34	34	0
30.	32	32	32	32	0	32.5	33	33	32.9	0.5	34	33.5	33.5	33.6	0.5
31.	32	32	32	32	0	33	33	33	32.3	0	33.5	34	33.5	33.6	0.5
Means.	30.8	31.2	31.3	31.2	0.50	32.5	32.5	32.5	32.5	0.06	34	34	34	34	0.03

Soil Temperature Records for 1896—April.

Dates	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean	Range.
1	39	42	38	39.3	4	34.5	36	35	35.1	1.5	33	33.5	33	33.1	0.5
2	33	42	28	30.7	14	32.5	36	32	33.1	4	32.5	34	32.5	33.3	1.5
3	27	35	26	28	7	31.5	31.5	31	31.3	0.5	32	32	32	32	0
4	29	34	30	30.7	5	30	32	31	31	2	32	32	32.5	32.3	0.5
5	31	42	30	33.3	12	31	32.5	32	31.9	1.5	32	32	32.5	32.3	0.5
6	38	42	32	36	10	32	35	32	32.7	3	32	33	33	32.7	1
7	31	40	28	31.7	12	32	32.5	32	32.1	0.5	32.5	32.5	33	32.7	0.5
8	34	41	32	34.7	9	32	33	32.5	32.5	1	32.5	34	35	34.1	2.5
9	34	44	34	36.5	10	32	37	33.5	34	5	32.5	36	34.5	34.4	3.5
10	34	40	36	36.5	6	32.5	34.5	34.5	34	2	33	33.5	35	34.1	2
11	38	42	40	40	4	34.5	38	37	36.6	3.5	34	36	36.5	35.7	2.5
12	42	60	52	51.5	18	37	50	48	45.7	13	35.5	43.5	46	42.1	8
13	49	72	58	59.3	23	43.5	56.5	55.5	52.7	13	41.5	50.5	53	49.5	11.5
14	62	65	53	58.3	12	52	57	53	53.7	5	48.5	53	53	51.9	4.5
15	54	75	58	61.3	21	47.5	63	58	56.6	15.5	46.5	56	57	54.1	10.5
16	60	76	61	64.5	16	53	64	60.5	59.5	11	51	58.5	60	57.4	9
17	69	69	68	68.5	1	59	69	64	64	10	54.5	63	63	60.9	8.5
18	74	89	66	73.7	23	59	69	63.5	63.7	10	56	63.5	63	61.4	7.5
19	68	87	69	73.3	19	58	66.5	63	62.6	8.5	56.5	61.5	62	60.5	5.5
20	62	82	62	67	20	55.5	65.5	62.5	61.5	10	55.5	62	62.5	60.6	7
21	60	74	66	66.5	14	57.5	63	58	59.1	5.5	57	59	59.5	58.7	2.5
22	47	60	46	49.7	14	46	51.5	52	50.4	6	49.5	52	55	52.9	5.5
23	48	64	56	56	16	46	57	64	57.7	18	47	54.5	56	53.4	9
24	48	50	48	48.5	2	49	50.5	49	49.4	1.5	51.5	51	50.5	50.9	1
25	47	56	50	50.7	9	47.5	50.5	51	50	3.5	48.5	49.5	51.5	50.3	3
26	56	67	56	58.7	11	50.5	59.5	57	56	9	50	56.5	58	55.6	8
27	53	58	52	54.7	6	52.5	55	53	53.3	2.5	53	54.5	54	54.3	1.5
28	50	60	55	55	10	50	56	56	54.5	6	51	53.5	56	54.1	5
29	53	68	58	59.3	15	52	62	59.5	58.3	10	52	58	59.5	57	7.5
30	59	66	57	59.7	9	55	61	56.5	57.3	6	54.5	59	58.5	57.6	4.5
Means	47.6	58.0	48.2	50.5	11.73	44.2	50.1	48.2	47.7	6.30	43.9	47.6	48.3	47.0	4.50

Soil Temperature—April—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m	8 p. m.	Mean.	Range.
1.	32	32.5	32.5	32.3	0.5	33	33	33	33	0	33.5	33.5	33.5	33.5	0
2.	32	32	32	32	0	33	33	33	33	0	33.5	33.5	33.5	33.5	0
3.	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
4.	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
5.	32	32	32.5	32.3	0.5	32.5	33	33	32.9	0.5	33.5	34	34	33.9	0.5
6.	32	33	33	32.7	1	33	33	33	33	0	34	34	34	34	0
7.	32	32.5	33	32.6	1	33	33	33	33	0	34	34	34	34	0
8.	32	33.5	33.5	33.1	1.5	33	33	33.5	33.3	0.5	34	34	34	34	0
9.	32.5	34.5	34.5	34	2	33.5	33.5	34.5	34	1	34	34	34	34	0
10.	33	33.5	34	33.5	1	34	34	34.5	34.3	0.5	34	34.5	34.5	34.4	0.5
11	33.5	34.5	35.5	34.7	2	34.5	34.5	35	34.7	0.5	34.5	34.5	34.5	34.5	0
12	35	39	42	39.5	7	35	36	37.5	36.5	2.5	35	35	35	35	0
13.	40	45	49.5	46	9.5	38.5	40	43	41.1	4.5	36	36.5	37	36.6	1
14.	47	48.5	50	48.5	3	44	44.5	46	45.1	2	38.5	39	39.5	39.1	1
15.	46	49.5	53	50.4	7	45	46	48	46.9	3	40.5	41	41	40.9	0.5
16.	49.5	52.5	56	53.5	6.5	48	48.5	51	49.6	3	42.5	43	43	42.9	0.5
17	52.5	56	59	56.6	6.5	50.5	51	53	51.4	2.5	44.5	44.5	45	44.7	0.5
18	55	58	60	58.4	5	53	53	55	54	2	46	46.5	47	46.6	1
19	55.5	57	59.5	57.9	4	54	54	55	54.5	1	48	48	48	48	0
20.	55	57.5	60	58.1	5	54.5	54	56	55.1	2	49	49	49	49	0
21	56.5	56.5	58	57.3	1.5	55	55	55.5	55.3	0.5	49.5	50	50	49.9	0.5
22	52	52	54.5	53.3	2.5	53.5	52.5	53	53	1	50	50.5	49.5	49.7	1
23	49	52	55	52.7	6	51	51	53	52	2	49.5	49.5	49.5	49.5	0
24	52	51	50.5	51	1.5	52.5	51.5	51	51	1.5	49.5	49.5	49.5	49.5	0
25	49	49	51	50	2	50	50	50.5	50.3	0.5	49	49	48.5	48.7	0.5
26	50	53	56	53.7	6	50	51	53	51.7	3	48.5	48.5	49	48.7	0.5
27.	53	53.5	54	53.6	1	53	52.5	53	52.9	0.5	49.5	49.5	49.5	49.5	0
28.	51.5	52	54.5	54.1	3	52	51.5	52.5	52.1	1	50	49.5	49.5	49.6	0.5
29	52.5	54.5	57	55.3	4.5	52.5	52.5	54.5	53.5	2	50	50	50	50	0
30	54.5	56	57.5	56.4	3	54	54	55	54.5	1	50.5	50.5	51	50.7	0.5
Means	43.7	45.2	46.7	45.6	3.13	43.7	43.8	44.8	44.3	1.28	41 6	41.7	41.8	41.7	0.30

Soil Temperature Records for 1896—May.

Dates.	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	52	58	54	54.5	6	52.5	55	54	53.9	2.5	53.5	54.5	55	54.5	1.5
2,	52	54	52	52.5	2	51.5	53	52.5	52.4	1.5	52.5	53	53	52.9	0.5
3,	56	68	58	60	12	53.5	60.5	59	58	7	52.5	57	58.5	56.6	6
4,	57	72	60	62.3	15	52.5	66.5	61.5	60.3	13	52	61	62.5	59.5	10.5
5,	59	73	58	62	15	56	65.5	59.5	60.1	9.5	56	62	62	60.5	6
6,	58	68	58	60.3	10	53.5	63.5	60	59.3	10	54	61	62	59.7	8
7,	56	66	56	58.5	10	55.5	62	59.5	59.1	6.5	56	59.5	61.5	59.6	5.5
8,	55	59	58	57.5	4	54	57	57.5	56.5	3.5	54.5	56	59	57.1	4.5
9,	64	82	66	69.5	18	57	69.5	65.5	64.4	12.5	55	64.5	65.5	62.6	10.5
10,	68	74	70	70.5	6	61	69.5	66.5	65.9	8.5	60	66	66.5	64.7	6.5
11,	74	79	66	71.3	13	64	70.5	67	67.1	6.5	61.5	66.5	67	65.5	5.5
12,	66	72	64	66.5	8	63	67.5	64	64.6	4.5	62	66.5	65	64.6	4.5
13,	60	77	66	67.3	17	59	69	66.5	65.3	10.5	59.5	65.5	67.5	65	8
14,	65	78	67	69.3	13	63	79.5	68	69.6	16.5	62.5	66	68	66.1	5.5
15,	66	74	60	65	14	63	67	64.5	64.7	4	63.5	66.5	67	66	3.5
16,	62	81	64	67.7	19	58	73.5	68	66.9	15.5	59	68	69	66.4	10
17,	71	84	65	71.3	19	64	73.5	67.5	68.1	9.5	63	69.5	69	67.6	6.5
18,	70	74	64	68	10	64	69	66	66.3	5	63	66.5	66.5	65.6	3.5
19,	70	74	60	66	14	64	67.5	63	64.4	4.5	62.5	64.5	64.5	64	2
20,	60	58	54	56.5	6	58	59	56	57.3	3	59.5	60.5	58.5	59.7	2
21,	54	60	60	58.5	6	54.5	58.5	59	57.7	4.5	56	57.5	59.5	58.1	3.5
22,	67	78	63	67.7	15	62	70	65	65.5	8	59.5	65.5	66	64.3	6.5
23,	63	64	64	63.7	1	60	67	66	64.3	7	60.5	65	67	63.4	6.5
24	65	74	60	64.7	14	61	70	65	65.3	9	60.5	66.5	66.5	65	6
25,	60	64	61	61.5	4	60	62.5	61.5	61.4	2.5	61	62	62	61.7	1
26,	65	79	65	68.5	14	63	70	66	66.3	7	62	66	67	65.5	5
27,	70	80	60	67.5	20	61.5	70	66	65.9	8.5	60.5	67	68	65.9	7.5
28,	65	77	62	67.5	15	62.5	70	65	65.6	7.5	62.5	66.5	67	65.7	4.5
29,	58	70	55	59.5	15	57.5	65	63	62.1	7.5	59	65	65.5	63.7	6.5
30,	56	72	61	62.5	16	53	67	64	63.3	9	59	65.5	65.5	63.9	6.5
31,	63	70	59	62.7	11	60	68	64	64	8	60.5	66.5	66.5	65	6
Means,	62.2	71.4	61.0	63.9	11.68	58.9	66.3	62.9	62.8	7.48	58 8	63.5	64.2	62.6	5.48

Soil Temperature—May—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	54	54	54.5	54.3	0.5	54.5	54	54	54.1	0.5	51	51	51	51	0
2,	52.5	52.5	52.5	52.5	0	53	53	53	53	0	51	51	51	51	0
3,	52	54	57	55	5	52.5	53	54.5	53.6	2	51	51	51	51	0
4,	52.5	56.5	60	57.3	7.5	53.5	54	56	54.9	2.5	51	51.5	51.5	51.4	0.5
5,	56	58.5	60.5	58.9	4.5	56	56	57.5	56.7	1.5	52	52.5	52.5	52.4	0.5
6,	55	58	61	58.7	6	56	56	57.5	56.7	1.5	53	53	53	53	0
7,	56.5	57.5	60	58.5	3.5	57	56.5	58	57.4	1.5	53.5	53.5	53.5	53.5	0
8,	55.5	56	58	56.9	2.5	56.5	56	56.5	56.4	0.5	54	54	53.5	53.7	0.5
9,	55	60	63	60	8	56	56	59.5	57.7	3.5	53	54	54	53.7	1
10,	59.5	62.5	64	62.5	4.5	59	59	61	60	2	54.5	54.5	55	54.7	0.5
11,	61	63	65	63.5	4	60	60	62	61	2	55.5	55.5	56	55.7	0.5
12,	62	64	64	63.5	2	61	61.5	62	61.6	1	56.5	56.5	56.5	56.5	0
13,	60	62.5	65.5	63.4	5.5	60.5	60.5	62.5	61.5	2	57	57	57	57	0
14,	62.5	66.5	66.5	64.7	4	62	62	63.5	62.7	1.5	57.5	57.5	57.5	57.5	0
15,	63.5	65	66.5	65.4	3	63	63	64	63.5	1	58	58	58.5	58.3	0.5
16,	60.5	65	67.5	65.1	7	62	62	64.5	63.3	2.5	59	59	58.5	58.7	0.5
17,	63.5	67.5	68	66.7	4.5	63.5	63.5	65.5	64.5	2	59	59.5	59.5	59.4	0.5
18,	63.5	65	66	65.1	2.5	64	64	64	64	0	60	60	60	60	0
19,	62.5	63.5	64	63.5	1.5	63	63	63	63	0	60	60	59.5	59.7	0.5
20,	60.5	60.5	60	60.3	0.5	61.5	61	61	61.1	0.5	59.5	59	59	59.1	0.5
21,	57	57.5	59	58.1	2	59	58.5	59	58.9	0.5	58.5	58	58	58.1	0.5
22,	59	62	64.5	63	5.5	59	60	62	60.7	3	58	57.5	57.5	57.6	0.5
23,	61	62.5	65	63.4	4	61	61	63	62	2	58.5	58.5	58.5	58.5	0
24,	61	63.5	65.5	63.9	4.5	62	62	63	62.5	1	59	59	59	59	0
25,	61.5	61.5	62	61.7	0.5	62	61.5	62	61.9	0.5	59.5	59.5	59	59.3	0.5
26,	61	63	65	63.5	4	61	61.5	63	62.1	2	59	59	59	59	0
27,	61.5	64	67	64.9	5.5	62	62	64	63	2	59.5	59.5	59.5	59.5	0
28,	62.5	64	66	64.6	3.5	63	63	64	63.5	1	60	60	60	60	0
29,	60.5	63	65	63.4	4.5	62	62	63	62.5	1	60	60	59.5	59.7	0.5
30,	60.5	63	65	63.4	4.5	62	62	63	62.5	1	60	60	59.5	59.7	0.5
31,	61	64	66	64.3	5	62	62	64	63	2	60	60	60	60	0
Means,	59.2	61.2	63.0	61.6	3.87	53.2	59.7	61.0	58.7	1.42	56.7	56.7	56.7	56.7	0.27

Soil Temperature Records for 1896—June.

Dates	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	59	67	56	59.7	11	56.5	65	62.5	61.6	6	57.5	65	65.5	63.4	8
2,	68	76	58	65	18	56.5	69	63.5	64.1	9	56.5	68.5	68.5	65.5	12
3,	65	86	68	71.7	21	58	77	68.5	68	19	58.5	69	70	66.9	11.5
4,	63	79	63	67	16	62.5	71	67.5	62.1	8.5	63.5	68	68.5	67.1	5
5,	68	85	66	71.3	19	63	74	70.5	69.5	11	63	71	72	69.5	9
6,	70	74	68	70	6	65.5	69.5	68	67.7	4	65	68.5	69.5	68.1	4.5
7,	69	70	70	69.7	1	65.5	68	68	67.4	2.5	65.5	69	68.5	67.9	3.5
8,	70	82	70	73	12	66	76	71.5	71.3	10	65	73.5	72	70.6	8.5
9,	70	81	70	72.8	11	67.5	75	70.5	70.9	7.5	67	73	72	71	6
10,	63	72	60	65.7	12	64.5	68	64	65.1	4	66	67.5	68	67.4	2
11,	64	75	60	64.7	15	59.5	68.5	64.5	64.3	9	59.5	68	67.5	65.6	8.5
12,	68	78	65	69	13	62	73	69.5	68.5	11	61	71	70.5	68.3	10
13,	64	60	58	60	6	62	62	60	61	2	63	63	62	62.5	1
14,	60	62	65	63	5	60	62	62.5	61.7	2.5	60.5	62	64	62.1	3.5
15,	60	78	64	66.5	8	59.5	68	66	64.9	8.5	60.5	67	67.5	65.6	7
16,	65	82	61	69.7	21	63	71.5	64	65.6	8.5	63	68.5	66	65.9	5.5
17,	60	76	66	67	16	61	71	69	67.5	10	62	69	70.5	68	8.5
18,	67	79	68	71.5	12	63	75	71	70	12	63	72.5	72.5	70.1	9.5
19,	72	84	72	75	12	66	77	73	72.3	11	65	74.5	73	71.4	9.5
20,	75	84	71	75.3	13	69	77.5	74	73.6	8.5	68	75	74.5	73	7
21,	75	86	70	75.3	16	70	79	71	72.7	9	68.5	75.5	72	72	7
22,	74	83	69	73.7	14	70	77	70.5	72	7	69	76	74	73.3	7
23,	62	74	61	64.5	13	63	72	65.5	66.5	11	64.5	71	68	67.9	6.5
24,	61	59	57	58.5	4	62	61	59.5	60.9	2.5	64	64.5	61.5	62.9	3
25,	60	66	62	62.5	6	58.5	64	63	62.1	5.5	60	63	63.5	62.5	3.5
26,	75	85	68	74	17	66.5	77	70	70.9	10.5	64	74	71.5	70.3	10
27,	64	76	65	67.5	12	64	72	69	68.5	8	64	70.5	70	68.6	6.5
28,	64	80	65	68.5	16	64	71.5	68.5	68.1	7.5	65	69	70	68.5	5
29,	69	74	63	67.3	11	64.5	71	66	66.9	6.5	63.5	70	69	67.9	6.5
30,	68	76	64	68	12	62	72	69	68	10	61	70.5	71	68.4	10
Means,	66.4	76.3	64.8	68.1	12.30	63.2	71.2	67.4	67.3	8.07	63.2	69.6	69.1	67.7	6.83

Soil Temperature—June—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	59.5	63	65	63.1	5.5	61.5	61.5	63	62.3	1.5	60	60	60	60	0
2	59	64	67	64.3	8	61	62.5	64	62.9	3	60	60	60	60	0
3	60.5	65	68	65.4	7.5	62.5	62.5	65	63.7	2.5	60.5	60.5	60.5	60.5	0
4.	64	65	67	65.7	3	64	64	65	64.5	1	61	61	61	61	0
5.	63	66.5	70	67.4	7	64	64	67	65.5	3	61	61.5	61.5	61.4	0.5
6	65	66.5	68	66.9	3	65.5	65.5	66	65.7	0.5	62	62	62	62	0
7.	64.5	67	67.5	66	3	65	65	66	65.5	1	62	62	62	62	0
8.	65	69	70.5	68.7	5.5	65	66	68	66.7	3	62	62.5	62.5	62.4	0.5
9.	67	69	71	69.5	4	67	67	68.5	67.7	1.5	63	63	63	63	0
10.	67	66.5	68	67.4	1.5	67	66.5	67	66.9	0.5	63.5	63.5	63.5	63.5	0
11.	62	65.5	67.5	65.6	5.5	64.5	64.5	66	65.3	1.5	63.5	63.5	64	63.7	0.5
12.	62	67	69	66.7	7	64	64.5	67	65.9	3	63	63	62.5	62.7	0.5
13.	64	64	63.5	63.7	0.5	65.5	65.5	64.5	64.9	1	63	63	63	63	0
14.	61	62	64	62.7	3	62	62.5	63.5	62.9	1.5	62.5	62	62	62.1	0.5
15.	61.5	64	66.5	64.6	5	62.5	63	63.5	63.1	1	62	62	62	62	0
16.	63.5	65.5	66.5	65.5	3	64	64.5	65	64.6	1	62	62	62	62	0
17	63	65.5	69	66.6	6	64	64	66	65	2	62	62.5	62.5	62.4	0.5
18	64	67.5	71	68.4	7	65	65	68	66.5	3	62.5	63	64	63.4	1.5
19.	65.5	70	72	69.9	6.5	67	67	69	68	2	63.5	63.5	63.5	63.5	0
20.	68	71	73	61.3	5	68	68	70	69	2	64	64.5	64.5	64.4	0.5
21.	68.5	71.5	72	71	3.5	69	69	70	69.5	1	65	65	65	65	0
22	68.5	72	73.5	71.9	5	69	69	71	70	2	65.5	65.5	65.5	65.5	0
23	66.5	69	69	68.4	2.5	69	68	69	68.7	1	66	66	66	66	0
24	66	66	64	65	2	67	67	65	66	2	65.5	65.5	65	65.3	0.5
25	61.5	62.5	64	63	2.5	64	63.5	64	63.9	0.5	64.5	64	63.5	63.9	1
26	63.5	68	70.5	68.1	7	64	65	67.5	66	3.5	63.5	63.5	63.5	63.5	0
27.	65	67.5	69	67.6	4	66	66	67	66.5	1	64	64	64	64	0
28.	63.5	67	69	67.6	3.5	66.5	66	68	67.1	2	64	64.5	64.5	64.4	0.5
29.	65	67.5	69	67.6	4	66.5	66	68	67.1	2	64.5	64.5	64.5	64.5	0
30	63	67	70	67.5	7	65.5	65.5	68	66.7	2.5	64.5	64.5	64.5	64.5	0
Means.	64.1	66.7	68.5	67.0	4.60	65.2	65.3	66.7	66.0	1.77	63.0	63.1	63.1	63.1	0.23

Soil Temperature Records for 1896—July.

Dates.	At Surface					One Inch.					Three Inches				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
3.	70	82	70	73	12	64.5	76	73	71.6	11.5	63.5	73.5	74.5	71.5	11
4.	76	85	72	76.3	13	68	79	74	73.7	11	66.5	76	76	73.6	9.5
5.	77	87	73	77.5	14	70	81	76	75.7	11	68.5	77.5	77	75	9
6.	71	82	72	74.3	11	70	78	73	73.5	8	70	76	74	73.5	6
7.	73	82	72	74.7	10	70.5	77	74	73.9	6.5	70.5	74.5	74.5	73.5	4
8.	72	80	72	74	8	69.5	76	73	72.9	6.5	69.5	74	74	62.9	4.5
9.	70	72	62	66.5	12	69.5	70	67	68.9	3	69.5	70	70	69.9	0.5
10.	67	72	64	66.7	8	63.5	70.5	66	66.5	7	64	69.5	65	65.9	5.5
11.	68	79	70	71.7	11	65	72	69.5	69	7	65	70	70	68.7	5
12.	71	79	71	73	8	65	75	71.5	70.5	10	63.5	73	72	70.1	9.5
13.	82	83	70	76.3	13	68	78	72	72.5	10	66	76	74	72.5	10
14.	76	88	74	78	14	69	80	75	74.5	11	68	77	76	74.3	9
15.	77	86	72	76.7	14	71	80	73	74.3	9	70	77.5	74	73.9	7.5
16.	65	84	74	74.3	19	69	77	74.5	73.7	8	69.5	75	74.5	73.4	5.5
17.	73	82	76	76.7	9	71	77	74	74	6	71	74.5	74.5	73.6	3.5
18.	68	74	66	68.5	8	66.5	73	69	69.4	6.5	68.5	74	72	71.6	5.5
19.	66	75	62	66.3	13	63	72	68	67.7	9	63.5	72	71	69.4	8.5
20.	66	78	66	69	12	63	74	70	69.3	11	63	73.5	72	70.1	10.5
21.	72	81	72	74.3	9	67	75.5	72.5	71.9	8.5	66	73.5	73	71.4	7.5
22.	73	78	70	70.3	8	70	73	71.5	71.5	3	69.5	72	72	71.4	2.5
23.	75	78	74	75.3	4	71.5	75.5	74	73.7	4	70.5	73.5	74	73	3.5
24.	76	80	72	75	8	72	77	74	74.3	5	71	75.5	74.5	73.9	4.5
25.	68	76	66	69	10	67	72.5	69	69.4	5.5	68	73.5	71.5	71.1	5.5
26.	60	65	68	65.3	8	62.5	64.5	66.5	65	4	65	65	66.5	65.7	1.5
27.	64	76	67	68.5	12	62	71	69	67.7	9	63.5	70.5	71	69	7.5
28.	68	81	70	72.3	13	64	74	71.5	70.3	10	64.5	72	72	70.1	7.5
29.	72	87	70	74.7	17	70	80	71.5	73.3	10	69	76.5	73.5	72.6	7.5
30.	72	81	72	74.3	9	69	76	74	73.7	7	69	73	74.5	72.7	5.5
31.	76	88	78	80	12	70.5	81.5	78	77	11	70	78	77.5	75.7	8
	74	84	70	74.5	14	71	80.5	73	74.4	9.5	71	78	75	74.7	7
	69	84	66	71.3	18	68	75	71.5	71.5	7	69	76	74	73.3	7
Means.	71.2	80.3	71.9	73.4	11.32	67.8	75.5	71.9	71.8	7.94	67.6	73.9	73.0	71.9	6.45

Soil Temperature—July—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	65	69	72.5	69.7	7.5	67	67	69	68	2	64.5	64.5	64.5	64.5	0
2,	67.5	71.5	75	72.3	7.5	68.5	68.5	71	69.7	2.5	65.5	65.5	65.5	65.5	0
3,	69	73	75	73	6	70	70	72	71	2	66	66.5	67	66.5	1
4,	70.5	73	73	72.4	2.5	71	71	72	71.5	1	67	67	67	67	0
5,	70.5	72	73.5	72.4	3	70.5	71	72	71.4	1.5	67.5	67.5	67.5	67.5	0
6,	70	71.5	75	72.9	5	70.5	70.5	71.5	71	1	67.5	67.5	67.5	67	0
7,	70	70	70.5	70.3	0.5	70	70	70	70	0	67.5	67.5	67.5	67.5	0
8,	66	68	68.5	67.7	2.5	68	68	68.5	68.3	0.5	67.5	67.5	67.5	67.5	0
9,	65	67	69	77.7	4	67	67	68	67.5	1	67.5	67	67	67.1	0.5
10,	65	68	71	68.7	6	67	67	69	68	2	66	66	66	66	0
11,	67	71	73	71	6	68.5	68.5	70	69.7	2.5	66.5	66.5	66.5	66.5	0
12,	68.5	72	74.5	72.4	6	69.5	70	71.5	70.6	2	67	67	67	67	0
13,	70	73.5	74	72.9	4	71	71	72	71.5	1	67.5	67.5	67.5	67.5	0
14,	70	71.5	73.5	72.1	3.5	71	71	72	71.5	1	68	68	68	68	0
15,	71	71.5	73.5	72.4	2.5	71	71	72	71.5	1	68	68	68	68	0
16,	70	71	73	72.3	3	71	70.5	71.5	71.1	1	68.5	68.5	68	68.3	0.5
17,	66.5	69	71	69.4	4.5	69	69	70	69.5	1	68	68	68	68	0
18,	65.5	70	72	69.9	6.5	68	68.5	70	69.1	2	68	67.5	67.5	67.6	0.5
19,	67.5	70.5	73	71	5.5	69	69	71	70	2	67.5	67.5	67.5	67.5	0
20,	70	70.5	71.5	70.9	1.5	70	70	71	70.5	1	68	68	68	68	0
21,	70	71	73	71.7	3	70	70.5	71.5	70.9	1.5	68	68	68	68	0
22	71	73	74	73	3	71	71	72	71.5	1	68.5	68.5	68.5	68.5	0
23,	70	71.5	72	71.4	2	71.5	71	72	71.6	1	68.5	68.5	68.5	68.5	0
24,	68	66.5	67	67.1	1.5	70	69	68	68.7	2	68.5	68.5	68	68.3	0.5
25,	65.5	68	70.5	68.6	5	67.5	67.5	69	68.3	1.5	67.5	67.5	67.5	67.5	0
26,	66	69	71	69.3	5	68	68	70	69	2	67.5	67.5	67.5	67.5	0
27	68	72.5	73	71.6	5	69	70	71.5	70.5	2.5	67.5	67.5	67.5	67.5	0
28	69.5	71	73.5	71.9	4	70.5	70	71.5	70.9	1.5	68	68	68	68	0
29,	70	73.5	76	73.9	6	71	71.5	73	72.1	2	68.5	68.5	68.5	68.5	0
30,	71.5	74	75	73.9	3.5	72	72.5	73.5	72.9	1.5	69.5	69.5	69.5	69.5	0
31,	70.5	72.5	74	72.7	3.5	72	72	73	72.5	1	69.5	69.5	69.5	69.5	0
Means,	69.2	70.8	72.6	71.3	4.16	69.7	69.7	71.0	69.9	1.48	67.6	67.6	67.5	67.6	0.10

Soil Temperature Records for 1896—August.

Dates.	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	67	72	66	67.7	6	65	71	68	68	6	66	71	70	69.3	5
2,	70	76	68	70.5	8	67.5	72	72	70.9	4.5	67.5	72	72	70.9	4.5
3,	68	80	72	74	12	66.5	78	74	73.1	11.5	67	76	76	73.7	9
4,	71	84	73	75.3	13	68	78	76	74.5	10	68.5	77	77	74.9	8.5
5,	74	86	77	78.5	12	71	83	78.5	77.7	12	70.5	80	79	77.1	9.5
6,	78	88	75	74	13	74	83	78	78.3	9	72.5	81	80	78.4	8.5
7,	78	82	74	77	8	74	80.5	75	76.1	6.5	73	79	76	77.5	6
8,	76	85	76	78.3	9	73	81.5	78	77.6	8.5	72.5	80	79	77.6	7.5
9,	79	89	75	79.5	14	75	83.5	78	78.6	8.5	74	81	81	79.3	7
10,	76	86	76	79	10	73.5	80	78	77.4	6.5	73.5	78.5	79	77.5	5.5
11,	78	84	73	77	11	73.5	84	78	78.4	10.5	73	83	80.5	79.3	10
12,	.....	.....	72	.....	.....	.....	.....	76	.....	.....	.....	.....	77.5	.....	.....
13,	71	71	72	71.5	1	71	73	71	71.5	2	72	74	72	72.5	2
14,	68	80	68	71	12	68.5	80	74.5	74.4	11.5	69	78	76.5	75	9
15,	68	92	70	75	24	68	84	75.5	75.7	16	68.5	81	78	76.4	12.5
16,	75	83	74	76.5	9	71.5	78	74	74.1	6.5	71.5	76.5	75	74.5	5
17,	62	74	60	64	14	63.5	75	68.5	68.9	11.5	66	75.5	72.5	71.6	9.5
18,	63	64	58	60.7	6	63	69	64.5	65.3	6	64	70	68	67.5	6
19,	57	68	56	59.3	12	60	68	64	64	8	62	69.5	68	66.9	7.5
20,	60	79	64	66.7	19	58	72	66	65.5	14	60	70.5	69	67.1	10.5
21,	65	73	64	66.7	9	63.5	71	67	65.4	7.5	64.5	69.5	68.5	67.7	5
22,	70	72	68	69.5	4	66	71.5	69	68.9	5.5	65.5	71	69.5	68.9	5.5
23,	72	84	70	74	14	69.5	76.5	71	72	7	69	74	72	71.7	5
24,	66	78	66	69	12	66.5	73.5	70	70	7	67.5	73	72.5	71.4	5.5
25,	64	80	64	68	16	63.5	76.5	70	70	13	64.5	75	73	71.1	10.5
26,	74	86	72	76	14	64.5	76	71.5	70.9	11.5	65.5	73.5	73	71.3	8
27,	62	76	60	64.5	16	63	70.5	66	66.4	7.5	66.5	72	70.5	69.9	5.5
28,	60	76	58	63	18	60	71.5	65.5	64.6	11.5	61.5	71.5	69.5	68	10
29,	58	78	58	63	20	58.5	73	67.5	66.6	14.5	60.5	71.5	70.5	68.3	11
30,	60	86	64	68.5	26	59.5	75.5	69	68.3	16	61.5	72.5	71.5	68.7	11
31	60	78	57	65	21	63	69	63.5	64.7	6	65.5	68.5	67	67	3
Means.	68.4	79.7	67.7	70.9	12.77	66.7	75.9	71.5	71.4	9.20	67.4	73.9	73.7	72.2	7.43

Soil Temperature—August—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	68	70	70.5	69.7	2.5	70.5	70	71	70.6	1	69.5	69.5	69	69.3	0.5
2,	68	70.5	72	70.6	4	70	70	71	70.5	1	69	69	68.5	68.7	0.5
3,	68	71.5	74.5	72.1	6.5	69.5	70	72	70.1	2.5	68.5	68.5	68.5	68.5	0
4,	69.5	73	75.5	73.4	6	71	71.5	73	72.1	2	69	69	69	69	0
5,	71	75	77	75	6	72	72	74.5	73.3	2.5	69.5	69.5	69.5	69.5	0
6,	73	76.5	79	76.9	6	73.5	73.5	75.5	74.5	2	70	70.5	70.5	70.4	0.5
7,	73.5	75.5	76	75.3	2.5	74	74	74.5	74.3	0.5	71	71	71	71	0
8,	72.5	76	78.5	76.4	6	73.5	73.5	75	74.3	1.5	71	71	71	71	0
9,	74	76.5	80	77.6	6	74.5	74.5	76	75.3	1.5	71.5	71.5	71.5	71.5	0
10,	74.5	76	78	76.6	3.5	75	75	76	75.5	1	72	72	72	72	0
11,	73.5	78	80	77.9	4.5	74.5	75	77	75.9	2.5	72	72	72	72	0
12,	.....	.....	78	.....	.....	.....	.....	77	.....	.....	.....	.....	72.5	72.5	.....
13,	73	73.5	73	73.1	0.5	74.5	74	74	74.1	0.5	72.5	72.5	72	72.3	0.5
14,	70.5	76	76	74.6	5.5	72.5	72.5	74	73.3	1.5	72	71.5	71.5	71.6	0.5
15,	70.5	75.5	77.5	74.3	7	72.5	73	74.5	73.6	2	71.5	71.5	71.5	71.5	0
16,	72	74	75	74	3	72.5	73.5	74	73.5	1.5	71.5	71.5	71.5	71.5	0
17,	69	72	76	73.3	7	72	71.5	73	72.4	1.5	71.5	71	71	71.1	0.5
18,	67	69	69.5	68.7	2.5	70.5	70	70.5	70.4	0.5	71	70.5	70	70.4	1
19,	65	67.5	69.5	67.9	4.5	68	68	69.5	68.7	1.5	69.5	69.5	69	69.3	0.5
20,	63	67	70	67.5	7	67	67	69	68	2	69	68.5	68.5	68.6	0.5
21,	66	68	69	68	3	68	68	69	68.5	1	68.5	68.5	68.5	68.5	0
22,	66	68.5	69.5	68.4	3.5	68	67.5	69	68.4	1.5	67.5	68	68	67.9	0.5
23,	68.5	71	72	70.9	3.5	69	70	71	70.3	2	68	68.5	68.5	68.4	0.5
24,	68.5	70.5	72.5	71	4	70	70	71	70.5	1	68.5	69	68.5	68.6	0.5
25,	67	71	73	71	6	69.5	69.5	71	70.3	1.5	69	69	68.5	68.7	0.5
26,	67.5	70.5	72.5	70.7	5	70	70	71	70.5	1	69	69	68.5	68.7	0.5
27,	69	70.5	71.5	70.6	2.5	70.5	70	71	70.6	1	68	68	69	68.5	1
28,	65	68.5	70.5	68.6	5.5	68.5	68	70	69.1	2	68	68.5	68.5	68.4	0.5
29,	63.5	68	70.5	68.1	7	67.5	67.5	69.5	68.5	2	68.5	68	68	68.1	0.5
30,	64.5	68.5	71	68.7	6.5	68	68	70	69	2	68	68	67.5	67.7	0.5
31,	67.5	67.5	68.5	68	1	69	68.5	68.5	68.6	0.5	68	68	68	68	0
Means,	69.0	71.9	73.7	72.1	4.60	70.9	70.9	72.3	71.6	1.50	69.8	69.8	69.7	69.8	0.33

Soil Temperature Records for 1896—September.

Dates.	At Surface.					One Inch.					Three Inches				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	58	72	52	59.5	20	56.5	68	62	62.1	11.5	58.5	67	66	64.9	8.5
2,	56	76	66	66	20	56	72	67	65.5	16	57.5	69	68	65.6	11.5
3,	68	74	62	59.5	20	65	76	66	68.3	11	64.5	72.5	68.5	68.5	8
4,	56	76	52	59.5	22	57	70.5	63	63.4	13.5	59.5	69.5	67	65.7	10
5,	58	59	60	59.4	2	59	59.5	60	59.6	1	61	61	61	61	0
6,	58	70	56	60	14	59	66	60	61.3	7	60.5	66	63	64.6	5.5
7,	58	68	56	59.5	12	56	67	62	61.7	11	57.5	66.5	64.5	63.3	9
8,	52	74	54	58.5	22	54.5	70.5	61.5	62	16	57	69	65	64	12
9,	56	76	60	63	20	56	70	65.5	64.3	14	57.5	69.5	68.5	66	12
10,	64	86	73	74	22	61.5	77.5	72	70.7	16	61.5	73.5	72.5	70	12
11,	72	92	73	77.5	20	68.5	83	73.5	74.6	14.5	67.5	78	75	73.9	10.5
12,	72	88	69	74.5	19	68.5	82.5	70.5	72.7	14	69	78.5	72.5	73.1	9.5
13,	66	76	65	68	11	67	69.5	67.5	67.9	2.5	68.5	69	69	68.5	0.5
14,	70	82	72	74	12	67	79	72	72.5	12	67.5	75.5	73	72.3	8
15,	67	74	65	67.7	9	67	71	67	68	4	68.5	70	68.5	68.9	1.5
16,	58	70	60	62	12	59	69	65	64.5	10	61	69	68.5	66.7	8
17,	64	68	64	65	4	63	73	67.5	67.7	10	64	70	69	68	6
18,	62	82	66	69	20	62.5	75.5	69	69	13	64	73	70.5	69.5	9
19,	66	68	50	58.5	18	66	68	56	61.5	12	67	68	61.5	64.5	6.5
20,	49	62	50	52.7	13	50	60.5	56	55.6	10.5	55	62	61	59.7	7
21,	49	68	60	61.3	19	51	64	60.5	59	13	54	62.5	62.5	60.4	8.5
22	56	54	48	51.5	8	57	60	53	55.7	7	58.5	61.5	57.5	58.7	4
23,	42	54	46	47	12	46	56	52	51.5	10	50.5	58	56.5	54.4	7.5
24,	49	65	50	53.5	16	48	62.5	56	55.6	14.5	50	61	59.5	57.5	11
25,	48	74	59	60	26	49	65.5	60.5	56.4	16.5	51.5	62.5	62	59.5	11
26,	58	74	61	63.5	16	58	59.5	62.5	60.1	6.5	57	66.5	64.5	65.5	9.5
27,	60	78	65	67	18	58.5	70.5	65.5	64	12	59	67.5	66	64.6	8.5
28,	58	65	60	63.3	7	58	61.5	60	59.9	3.5	61	61	61.5	61.3	0.5
29,	61	64	63	62.7	3	61	62	62	61.7	1	61	62	62	61.7	1
30.	52	54	53	53	2	55	59	55.5	56.3	4	57.5	61	58	58.6	3.5
Means	58.8	71.6	59.7	62.5	14.63	58.6	68.3	63.0	63.2	10.25	60.2	67.3	65.4	64.6	7.33

Soil Temperature—September—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	62	65	67	65.3	5	66	66	67	66.5	1	67.5	67.5	67	67.3	0.5
2.	61.5	65.5	68	65.7	6.5	65	65	67	66	2	67	67	66.5	66.7	0.5
3.	65.5	69	69	68.1	3.5	67	67.5	68.5	67.9	1.5	66.5	66.5	66.5	66.5	0
4.	63	66	68.5	66.5	5.5	66.5	66	67.5	66.9	1.5	66.5	66.5	66.5	66.5	0
5.	63	62.5	62.5	62.6	0.5	65.5	65	64.5	64.9	1	66.5	66.5	66	66.3	0.5
6.	62	64.5	65	64.1	3	64	64.5	65.5	64.9	1.5	65.5	65.5	66	65.7	0.5
7.	60.5	64	65	63.6	4.5	64	64	65	64.5	1	65	65	65	65	0
8.	60	64.5	66	64.1	6	63	63.5	65.5	64.4	2.5	65	64.5	64.5	64.9	0.5
9.	60.5	65.5	68	65.5	7.5	64	64	66	65	2	64.5	64.5	64.5	64.5	0
10.	63	68	71	68.3	8	65	65.5	68	66.6	3	65	65	65	65	0
11.	68	72.5	73.5	71.7	5.5	68	68.5	71	69.6	3	65.5	66	66	65.9	0.5
12.	69.5	73	72.5	71.9	3.5	70	70	66	68	4	67	67	67	67	0
13.	69	69	69.5	69.3	0.5	70	69	69.5	69.5	1	67.5	67.5	67.5	67.5	0
14.	67.5	71	72	70.6	4.5	69	69	70.5	69.7	1.5	67.5	67.5	67.5	67.5	0
15.	69	69	69.5	69.3	0.5	69.5	69	69.5	69.4	0.5	67.5	67.5	67.5	67.5	0
16.	64	67	69	67.3	5	67	67	68	67.5	1	67.5	67	67	67.1	0.5
17.	65.5	67.5	69	67.7	3.5	67	67	68	67.5	1	67	67	67	67	0
18.	65.5	69	70.5	68.9	5	67	67.5	69	68.1	1.5	66.5	67	66.5	66.6	0.5
19.	67.5	67.5	65	66.3	2.5	68	68	67.5	67.7	0.5	67	67	67	67	0
20.	59	61.5	63	61.6	4	64	63	64	63.7	1	66.5	66	65.5	65.9	1
21.	57.5	60.5	63.5	61.3	6	62	61.5	63	62.4	1.5	65	64.5	64	64.4	1
22.	60	61	60	60.3	1	63	62.5	62	62.4	1	64	64	63.5	63.7	0.5
23.	55	57.5	58.5	57.4	3.5	60	59.5	60	59.9	0.5	63	63	62.5	62.7	0.5
24.	54	58	60.5	58.3	6.5	58.5	58	60	59.1	2	62	62	61.5	61.7	0.5
25.	55	59.5	62	59.6	7	58	58	61	59.5	3	61.5	61.5	61	61.3	0.5
26.	59.5	62.5	64.5	62.7	5	60.5	61	63	61.9	2.5	61	61.5	61.5	61.4	0.5
27.	60.5	63.5	65.5	63.7	5	62	62	63.5	62.7	1.5	62	62	62	62	0
28.	62.5	61.5	62	62	1	63.5	62.5	63	63	1	62.5	62.5	62.5	62.5	0
29.	61.5	62	62	61.9	0.5	62.5	62.5	62.5	62.5	0	62.5	62.5	62.5	62.5	0
30.	60	61	60	60.3	1	62	61.5	62	61.9	0.5	62	62	62	62	0
Means.	62.4	64.9	66.1	64.9	4.03	64.7	64.6	65.6	65.1	1.52	65.1	65.1	65.0	65.1	0.28

Soil Temperature Records for 1896—October.

Dates	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	52	60	55	55.5	8	52	67.5	55.5	55.1	5.5	55	58	57.5	57	3
2,	52	62	50	53.6	12	52.5	60.5	55	55.7	8	55	61.5	59.	58.6	6.5
3,	46	60	50	51.5	14	48	59.5	54	53.9	11.5	51	59.	57	56.1	8.5
4,	50	58	50	52	8	51	56	54	53.7	5	53.5	56.5	55.5	55.3	3
5,	50	60	45	50	15	51.5	57	52	53.1	5.5	53	57	50.5	52.3	6.5
6,	46	60	53	63	14	47	57	54	53	10	49.5	56.5	56	54.5	7
7,	46	48	43	45	5	48	50	46	47.5	4	51	52	50	50.7	
8,	43	52	40	43.7	12	45	51	46	46.7	12	47.5	52	50	49.9	4.5
9,	37	52	40	42.3	15	41	51.5	46	46.1	10.5	44	51	50.5	49	7
10,	37	55	42	44	18	40.5	52.5	47	46.7	12	43.5	52	50.5	49.1	8.5
11,	42	56	45	47	14	43	53	49	48.5	10	45	51.5	51	49.4	6.5
12,	42	44	43	43	2	44	46	45	45	2	47	47.	47	47.1	0.5
13,	45	48	44	45.3	4	46	48.5	47	47.1	2.5	47	49.	48.5	48.4	2.5
14,	48	48	46	47	2	47	48.5	47	47.4	1.5	47.5	49.5	48.5	48.5	2
15,	44	60	48	50	16	44	53	50	47.7	9	46	53	52	50.7	7
16,	48	56	46	49	10	47.5	53.5	49	48.7	6	48	53	51	50.7	5
17,	45	56	46	48.3	11	45	52	49	48.7	7	47	51.5	50.5	49.9	4.5
18,	45	42	36	39.7	9	46	44.5	41.5	43.4	4.5	47	47	45	46	2
19,	35	48	34	37.7	14	37	44	40.5	40.5	7	40.5	45	44	43.4	4.5
20,	42	50	50	48	8	42	48.5	47	46.1	6.5	43.5	47.5	47.5	46.5	4
21,	48	50	36	42.5	14	46.5	47.5	42	44.5	5.5	47	49	45.5	46.7	3.5
22,	36	52	40	42	16	38	48.5	44	43.6	10.5	40	47	45	44.3	7
23,	37	46	45	43.3	9	38.5	46	45	43.6	7.5	41	45.5	46	44.6	5
24,	38	42	34	37	8	41	42.5	39	40.4	3.5	43	44.5	42	42.9	2.5
25,	34	52	34	38.5	18	36	47.5	41.5	41.6	11.5	38.5	46.5	44	43.3	8
26,	34	58	40	43	24	35.5	48.5	43	42.5	13	38.5	47	45.5	44.1	8.5
27,	40	56	42	45	16	39.5	49	47	45.6	9.5	41	49	48.5	46.7	8
28,	42	62	52	52	20	42	53	51	49.3	11	43	50	50.5	48.5	7.5
29,	52	70	54	57.5	18	49	60.5	54.5	54.6	11.5	48.5	56.5	55	43.7	8
30,	58	70	58	61	12	53	59	56.5	56.3	6	52.5	56	56	45.1	3.5
31,	52	66	48	53.5	18	51	58	51	52.7	7	51.5	56.5	53	53.5	5
Means,	44.1	54.8	44.8	47.1	12.39	44.8	51.7	48.1	48.2	7.45	46.6	51.6	50.1	49.6	5.23

Soil Temperature—October—Continued.

Dates	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1,	57	58	59	58.3	2	60	60	60	60	0	61.5	61.5	61.5	61.5	0
2,	57	59.5	60.5	59.4	3.5	59	59.5	60.5	59.9	1.5	61	61	60.5	60.7	0.5
3,	55	57.5	58.5	57.4	3.5	58.5	58.5	59	58.7	0.5	60.5	60.5	60	60.3	0.5
4,	55.5	56	57	56.4	1.5	58	58	58	58	0	60	60	60	60	0
5,	55	56	57	56.3	2	57.5	57.5	58	57.7	0.5	59.5	59.5	59.5	59.5	0
6,	52.5	55	56.5	55.1	4	56.5	56	57	56.6	1	59	59	59	59	0
7,	54	53.5	53	53.4	1	57	56	56	56.3	1	58.5	58.5	58.5	58.5	0
8,	50.5	52	53	52.1	2.5	54	54	54.5	54.3	0.5	57.5	57.5	57	57.3	0.5
9,	48	50	52.5	50.7	4.5	52.5	52.5	54	53.3	1.5	56.5	56.5	56	56.3	0.5
10,	47.5	50	52	50.4	4.5	52	52	53	52.5	1	56	56	55.5	55.7	0.5
11,	48	50	52	50.5	4	51.5	51.5	53	52.3	1.5	55	55	55	55	0
12,	49	48.5	48.5	48.6	0.5	52	51	51.5	51.5	1	55	54.5	54.5	54.6	0.5
13,	48.5	49.5	49.5	49.3	1	51	51	51.5	51.3	0.5	54	54	54	54	0
14,	49	50	50	49.7	1	51	51.5	51.5	51.4	0.5	53.5	53.5	53.5	53.5	0
15,	48	50.5	52.5	50.9	4.5	51	51	52.5	51.7	1.5	53.5	53.5	53.5	53.5	0
16,	50	51.5	52	51.4	2	52	52	53	52.5	1	53.5	53.5	53.5	53.5	0
17,	49	50.5	51.5	50.6	2.5	52	51.5	52	51.9	0.5	53.5	53.5	53.5	53.5	0
18,	48.5	48.5	47.5	48	1	51.5	51	50.5	50.9	1	53.5	53.5	53	53.3	0.5
19,	44	45.5	46	45.4	2	48.5	48	48.5	48.4	0.5	52.5	52.5	53	52.7	0.5
20,	45	46	48	46.7	3	48	48	49	48.5	1	51.5	51.5	51.5	51.5	0
21,	47.5	48.5	48	48	1	49.5	50	50	49.9	0.5	51.5	51.5	51.5	51.5	0
22,	43.5	45.5	47	45.7	3.5	48	47.5	48.5	48.1	1	51	51	50.5	50.7	0.5
23,	44	45.5	46.5	45.6	2.5	47.5	47.5	48	47.7	0.5	50.5	50.5	50.5	50.5	0
24,	45	45.5	44	44.6	1.5	48	47.5	47.5	47.6	0.5	50	50	50	50	0
25,	42	44.5	45.5	44.4	3.5	46	45.5	47	46.6	1.5	49.5	49.5	49	49.3	0.5
26,	41.5	44.5	46	44.5	4.5	45.5	45.5	47	46.3	1.5	49	49	48.5	48.7	0.5
27,	43	47	48.5	46.7	5.5	46	48	49	48	3	49	49	49	49	0
28,	45	47	49.5	47.7	4.5	47.5	47.5	49	48.3	1.5	49	49	49	49	0
29,	49	52	54	52.3	5	49.5	50	52	50.9	2.5	49.5	50	50	49.9	0.5
30,	52	53.5	55	53.9	3	52	52.5	53	52.6	1	50.5	51	51	50.9	0.5
31	52.5	54	53.5	53.4	1.5	53	53	53.5	53.3	0.5	51.5	52	52	51.9	0.5
Means,	48.9	50.5	51.4	50.6	2.81	51.8	51.8	52.5	52.2	1.00	54.5	54.1	54.0	54.1	0.23

Soil Temperature Records for 1896—November.

Dates.	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	50	64	48	52.5	16	48	55	49.5	50.5	7	48.5	54	51.5	51.4	5.5
2.	46	64	48	51.5	18	45	57	50.5	50.7	12	46.5	54	52	51.1	7.5
3.	43	62	50	51.3	19	44.5	55	50.5	50.1	10.5	46.5	53	50.5	50.1	6.5
4.	54	54	54	54	0	50	52	53	52	3	50	51.5	52	51.4	2
5.	60	62	44	52.5	18	56.5	59	49	53.4	10	55.5	57.5	53	54.7	4.5
6.	39	54	42	44.3	15	42	49.5	45	45.4	7.5	45	50	47.5	47.5	5
7.	36	60	49	48.5	24	40	51	49	47.3	11	42.5	49.5	50	48	7.5
8.	37	42	34	36.3	8	41.5	44.5	39	41	5.5	45	46	43	44.3	3
9.	32	36	30	32	6	36	37.5	36	36.4	1.5	39	40.5	39.5	37.1	1.5
10.	29	42	40	37.7	13	34	40	39.5	38.3	6	32	39.5	40.5	38.1	8.5
11.	42	50	43	44.5	8	41	45.5	44.5	43.9	4.5	41.5	44.5	45	44	3.5
12.	42	46	36	40	10	43.5	44.5	40.5	42.3	4	44	44.5	43	43.6	1.5
13.	39	36	30	33.7	9	37	37.5	34.5	35.9	3	39	40	38	38.7	2
14.	30	37	30	31.7	7	33.5	36	34.5	34.6	2.5	36	37	37	36.7	1
15.	34	48	38	39.5	14	34	43.5	40	39.4	9.5	36	41.5	41.5	40.1	5.5
16.	44	60	48	50	16	42	52	48	47.5	10	41.5	48	48	46.6	6.5
17.	54	58	50	53	8	48.5	53.5	50	50.5	5	47	50.5	49.5	49.1	3.5
18.	48	62	54	54.5	14	47	57	52.5	52.3	10	48	53.5	52	51.4	5.5
19.	48	46	36	41.5	12	50	47.5	41.5	45.1	8.5	51	49	45.5	47.7	5.5
20.	30	35	34	33.3	5	35.5	37.5	37	36.7	2	39.5	40	39.5	39.6	0.5
21.	36	41	42	40.3	6	37	40	42	40.3	5	38.5	40	42	40.6	3.5
22.	38	41	32	34.7	9	39	41	37	38.5	4	40.5	41.5	40.5	40.7	1
23.	31	38	37	35.7	7	34	36.5	37.5	36.4	3.5	37	37.5	38.5	37.9	1.5
24.	40	54	48	47.5	14	39	48.5	47	45.4	9.5	39.5	44.5	46	44	6.5
25.	45	59	50	51	14	44	52.5	49.5	48.9	8.5	44	49	49	47.7	5
26.	45	61	55	54	16	47	55	53	52	8	47	52	52	50.7	5
27.	56	62	58	58.5	6	53	58	55.5	55.5	5	52	55	54.5	54	3
28.	48	54	39	45	15	51	47.5	44	46.6	7	52.5	50	46	48.6	6.5
29.	32	34	31	32	3	36.5	37.5	36	36.5	1.5	40.5	40.5	39.5	40	1
30.	26	30	29	28.5	4	33	33.5	32	33.4	1.5	36.5	36.5	36	36.3	0.5
Means.	41.1	49.7	42.0	43.7	11.13	42.1	46.9	43.9	44.2	6.23	43.4	46.4	45.4	45.7	4.00

Soil Temperature—November—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	50	51.5	52	51.4	2	52	51.5	52	51.9	0.5	52	52	52	52	0
2.	48.5	50.5	52.5	51	4	51	51	52	51.5	1	52	52	51.5	51.7	0.5
3.	48.5	50.5	52	50.7	3.5	51	51	52	51.5	1	52	52	51.5	51.7	0.5
4.	50	51	51.5	51	1.5	51	51	52	51.5	1	51.5	52	52	51.9	0.5
5.	55.5	56	55.5	55.4	0.5	54	53.5	54.5	54.1	1	52	52	52.5	52.3	0.5
6.	48.5	49	49	48.9	0.5	52	51	51	51.3	1	52.5	52.5	52	52.3	0.5
7.	45.5	48	50	48.4	4.5	49	49	50	49.5	1	51.5	51.5	51	51.3	0.5
8.	47	46.5	46	46.4	1	49.5	49	49	49.1	0.5	51	51	50.5	50.3	0.5
9.	42.5	42.5	42	42.3	0.5	46.5	46	45.5	45.9	1	50	50	49.5	49.7	0.5
10.	40	40.5	42	41.1	2	44	44	44	44	0	49	48.5	48	48.4	0.5
11.	41.5	44	45.5	44.1	4	42.5	45	46	44.9	3.5	48	48	48	48	0
12.	44.5	44.5	44.5	44.5	0	46	46	46.5	46.3	0.5	48	48	48	48	0
13.	41.5	41.5	41	41.3	0.5	45	44.5	44	44.4	1	48	47.5	46.5	47.1	1.5
14.	39	39	39	39	0	43	42.5	42.5	42.6	0.5	46	46.5	46.5	46.4	0.5
15.	38	40	42	40.5	4	41.5	42	43	42.4	1.5	46	46	45.5	45.7	0.5
16.	42	44.5	48	45.6	6	43	44	46.5	45	3.5	45.5	46	46	45.9	0.5
17.	46	48	49	48	3	46	47	48	47.3	2	46.5	46.5	47	46.7	0.5
18.	48	50	51	50	3	48	48.5	49.5	48.9	1.5	47.5	47.5	48	47.7	0.5
19.	50	49.5	48	48.9	2	50	50	50	50	0	48.5	48.5	48.5	48.5	0
20.	42.5	42	41.5	41.9	1	46.5	45.5	45	45	1.5	48.5	48.5	48	48.3	0.5
21.	40.5	41	42	41.4	1.5	44	44	44	44	0	47.5	47	47	47.1	0.5
22.	42.5	42	42	42.1	0.5	44.5	44	44	44.1	0.5	46.5	46.5	46.5	46.5	0
23.	39.5	39	39.5	39.4	0.5	42	42.5	42.5	42.4	0.5	46	46	46	46	0
24.	40.5	42	44.5	42.9	4	42.5	43	44.5	43.6	2	45.5	45.5	45	45.3	0.5
25.	44	46	48	46.5	4	45	45.5	47	46.1	2	45.5	46	46	45.9	0.5
26.	47.5	49	50.5	49.4	3	47.5	47.5	49	48.3	1.5	46.5	47	47	46.9	0.5
27.	50.5	52	53	52.1	2.5	49.5	50	51	50.4	1.5	47.5	48	48	47.9	0.5
28.	52.5	50.5	49	50.3	3.5	51.5	51	50	50.6	1.5	48.5	49.5	49.5	49.3	1
29.	44	43	42	42.7	2	47.5	46	45.5	46.1	2	49	48.5	48.5	48.6	0.5
30.	40	39	37.5	38.5	2.5	44	43	43	43.5	1	47.5	47	47	47.1	0.5
Means.	45.0	45.7	46.3	45.8	2.27	47.5	47.0	47.5	47.3	1.20	48.5	48.6	48.4	48.6	0.45

Soil Temperature Records for 1896—December.

Dates	At Surface.					One Inch.					Three Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
2	23	26	24	24.3	3	30	31.5	30.5	30.6	1.5	34	34.5	34	34.1	0.5
3	20	26	23	23	6	29	30.5	30	29.9	1.5	33.5	33.5	33	33.3	0.5
4	18	32	20	22.5	14	28	31.5	29.5	29.6	3.5	32.5	32.5	32.5	32.5	0
5	27	32	28	28.7	5	27	31.5	30	29.6	4.5	32	32	32	32	0
6	31	37	33	33.5	6	31	32	32	31.7	1	32	32	32.5	32.3	0.5
7	32	42	32	34.5	10	32	33	32	32.3	1	32.5	32.5	32.5	32.5	0
8	33	42	34	35.7	9	32	34.5	33.5	33.1	2.5	33	33.5	34.5	33.9	1.5
9	32	36	37	35.5	5	32.5	33.5	35	34	2.5	34	34.5	35	34.6	1
10	36	36	37	36.5	1	37	37	36	36.5	1	37.5	37.5	37	37.3	0.5
11	38	45	41	41.3	7	36.5	42	40	39.6	5.5	37	41	40	39.5	4
12	38	40	36	37.5	4	37.5	39.5	37.5	38	2	38.5	39	39	39	1
13	32	46	38	38.5	14	34	41	38.5	38	7	35.5	38.5	39	38	3.5
14	35	52	44	43.7	17	34.5	44.5	42	40.7	10	36	41	41.5	40	5.5
15	30	40	31	33	10	34.5	38.5	35	35.7	4	37	38.5	37.5	37.6	1.5
16	32	36	30	32	6	33.5	34.5	34	34	1	35.5	36	35.5	35.6	0.5
17	28	34	24	27.5	10	32	32.5	32	32.1	0.5	34.5	34.5	34.5	34.5	0
18	26	38	28	31	18	30	32	32	31.5	2	33.5	33.5	33.5	33.5	0
19	32	34	33	33	2	32	32	32	32	0	33.5	33.5	33.5	33.5	0
20	28	34	27	29	7	31	31.5	31	31.1	0.5	33.5	33.5	33.5	33.5	0
21	23	29	26	26	6	28.5	31.5	30	30	3	33	33	33	33	0
22	28	28	26	27	2	30.5	31.5	30	30.5	1.5	32.5	33	32.5	32.6	0.5
23	26	30	30	29	4	29.5	31	31	30.6	1.5	32.5	32.5	32.5	32.5	0
24	28	26	26	26.5	2	31	30	27	28.7	4	32.5	32.5	32	32.3	0.5
25	16	20	20	19	4	28	27.5	28.5	28.1	1	32	31.5	31.5	31.6	0.5
26	22	26	19	21.5	7	28	28.5	27	27.6	1.5	31	31	31	31	0
27	28	30	29	29	2	28.5	30	30	29.6	1.5	30.5	31.5	31.5	31.3	1
28	22	27	18	21.3	9	28	29	26	27.3	3	31	31	31	31	0
29	13	28	24	22.3	15	23	29	28	27	6	28.5	30	31	30.1	2.5
30	23	26	34	29.3	11	26.5	31.5	32	30.5	5.5	29.5	31	32	31.1	2.5
31	34	37	36	35.7	3	32	32	32	32	0	32	32	32	32	0
Means.	36	40	30	34	10	32.5	33.5	32	32.5	1.5	32	32	32	32	0
	27.9	34.0	29.6	30.3	7.39	31.0	33.2	32.1	32.1	2.63	33.3	34.0	34.0	33.8	0.90

Soil Temperature—December—Continued.

Dates	Six Inches.					Twelve Inches					Twenty-four Inches.				
	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.	8 a. m.	2 p. m.	8 p. m.	Mean.	Range.
1.	37	37	36.5	36.7	0.5	41	41	40	40.5	1	46	45.5	45.5	45.6	0.5
2.	36	35.5	35.5	35.6	0.5	40	39.5	39	39.4	1	44.5	44.5	44	44.3	0.5
3.	35	35	35	35	0	39	38.5	38.5	38.6	0.5	43.5	43	43	43.1	0.5
4.	34.5	34.5	34.5	34.5	0	38	38	38	38	0	42.5	42.5	42	42.3	0.5
5.	34.5	34	34	34.1	0.5	37.5	37.5	37.5	37.5	0	42	41.5	41.5	41.6	0.5
6.	34	34.5	34	34.1	0.5	37.5	37.5	37	37.3	0.5	41.5	41.5	41	41.3	0.5
7.	34.5	34.5	35.5	35	1	37	37.5	38	37.6	1	41	41	41	41	0
8.	35	35	35.5	35.3	0.5	37.5	37.5	37.5	37.5	0	40.5	40.5	40.5	40.5	0
9.	37.5	37.5	37.5	37.5	0	38.5	38.5	39	38.7	0.5	40.5	40.5	40.5	40.5	0
10.	37.5	39	40	39.1	2.5	39	39.5	40.5	39.9	1.5	41	41	41	41	0
11.	38	39.5	39.5	39.3	1.5	40.5	40.5	40.5	40.5	0	41.5	41.5	41.5	41.5	0
12.	37	37.5	39	38.1	2	40	39.5	40	39.9	0.5	41.5	41.5	41.5	41.5	0
13.	37	39	41	39.5	4	39.5	39.5	41	40.3	1.5	41.5	41.5	41.5	41.5	0
14.	38.5	38.5	37.5	38	1	40.5	40	40	40.1	0.5	41.5	41.5	41.5	41.5	0
15.	36.5	36.5	36.5	36.5	0	39	39	39	39	0	41.5	41.5	41.5	41.5	0
16.	36.5	35.5	35.5	35.7	1	38.5	38	38	38.1	0.5	41	41	41	41	0
17.	35	34.5	33.5	34.6	0.5	37.5	37.5	37	37.3	0.5	41	40.5	40.5	40.6	0.5
18.	34.5	34.5	34.5	34.5	0	37	37	37	37	0	40	40	40	40	0
19.	34.5	34.5	34.5	34.5	0	37	37	37	37	0	40	40	39.5	39.7	0.5
20.	34	34	34	34	0	36.5	36.5	36.5	36.5	0	39.5	39.5	39.5	39.5	0
21.	33.5	34	33.5	33.6	0.5	36	36	36	36	0	39	39	39	39	0
22.	33.5	33.5	33.5	33.5	0	36	36	36	36	0	39	39	39	39	0
23.	33.5	33.5	33.5	33.5	0	35.5	36	36	35.9	0.5	38.5	38.5	38.5	38.5	0
24.	33	33	33	33	0	35.5	35.5	35.5	35.5	0	38.5	38.5	38.5	38.5	0
25.	33	33	33	33	0	35.5	35.5	35	35.3	0.5	38.5	38	38	38.1	0.5
26.	32.5	32.5	32.5	32.5	0	35	35	35	35	0	38	38	38	38	0
27.	32.5	32.5	32.5	32.5	0	35	35	35	35	0	38	38	38	38	0
28.	32.5	32.5	32	32.3	0.5	35	35	35	35	0	37.5	37.5	37.5	37.5	0
29.	32	32	32	32	0	34.5	34.5	34.5	34.5	0	37.5	37.5	37.5	37.5	0
30.	32.5	32	32.5	32.4	0.5	34.5	34.5	34.5	34.5	0	37.5	37.5	37.5	37.5	0
31.	32.5	32.5	32.5	32.5	0	34.5	34.5	34.5	34.5	0	37.5	37.5	37.5	37.5	0
Means.	34.8	34.9	35.0	34.9	0.56	37.4	37.3	37.4	37.4	0.34	40.4	40.3	40.2	40.3	0.15